US007654431B2

(12) **United States Patent**
Hueil et al.

(10) **Patent No.: US 7,654,431 B2**
(45) **Date of Patent: *Feb. 2, 2010**

(54) **SURGICAL INSTRUMENT WITH GUIDED LATERALLY MOVING ARTICULATION MEMBER**

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(73) Assignee: **Ethicon Endo-Surgery, Inc.**, Cincinnati, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 30 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/100,847**

(22) Filed: **Apr. 7, 2005**

(65) **Prior Publication Data**

US 2006/0226196 A1 Oct. 12, 2006

Related U.S. Application Data

(63) Continuation-in-part of application No. 11/061,908, filed on Feb. 18, 2005.

(51) **Int. Cl.**
A61B 1/00 (2006.01)

(52) **U.S. Cl.** **227/175.1**; 227/175.2; 227/176.1; 227/19; 227/181.1; 227/182.2; 606/139; 606/142; 606/143; 606/205; 606/206; 606/207; 606/219

(58) **Field of Classification Search** 227/175.1, 227/175.2, 176.1, 19, 181.1, 182.2; 606/32, 606/38–42, 139–144, 170–174, 205–207
See application file for complete search history.

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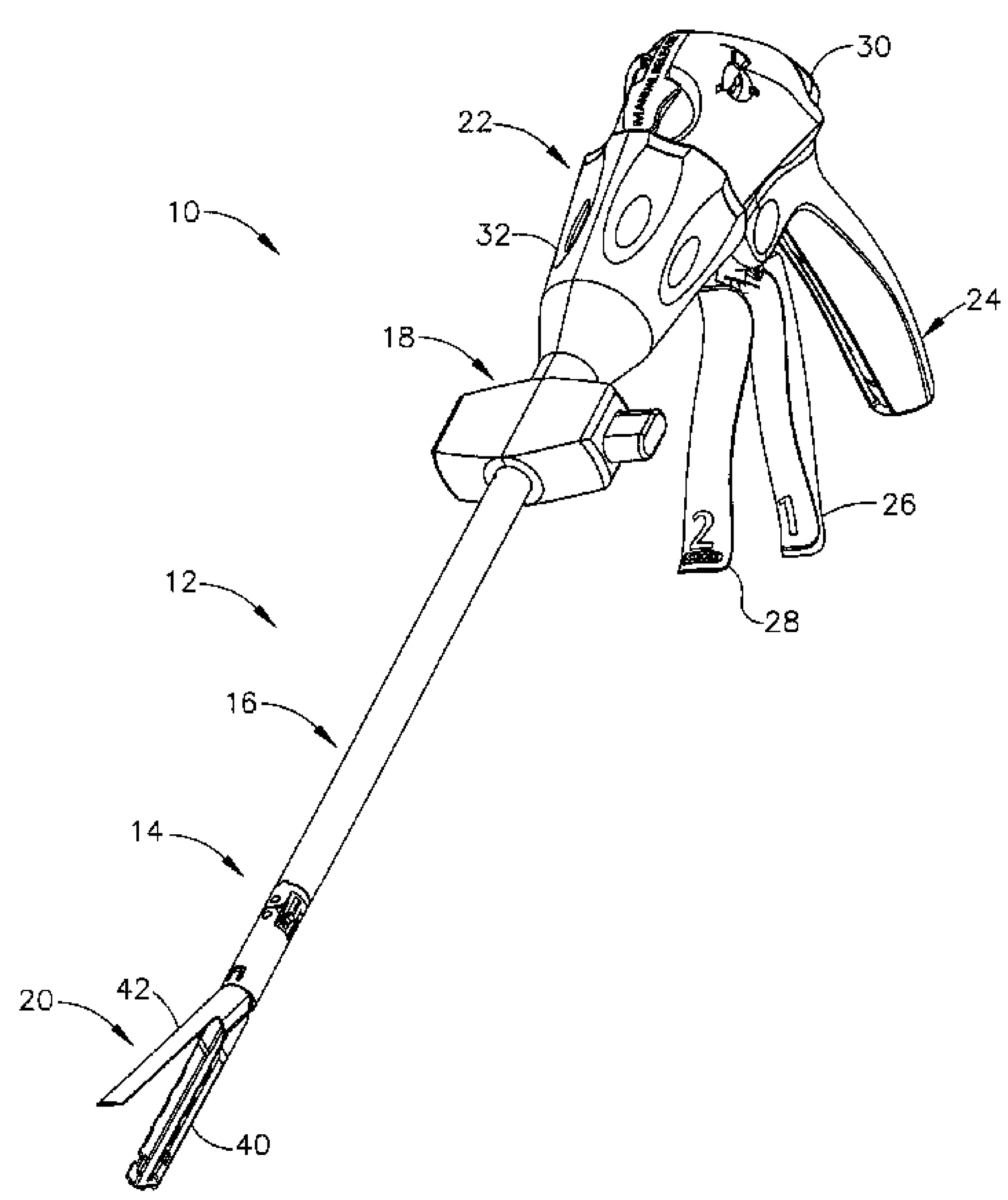
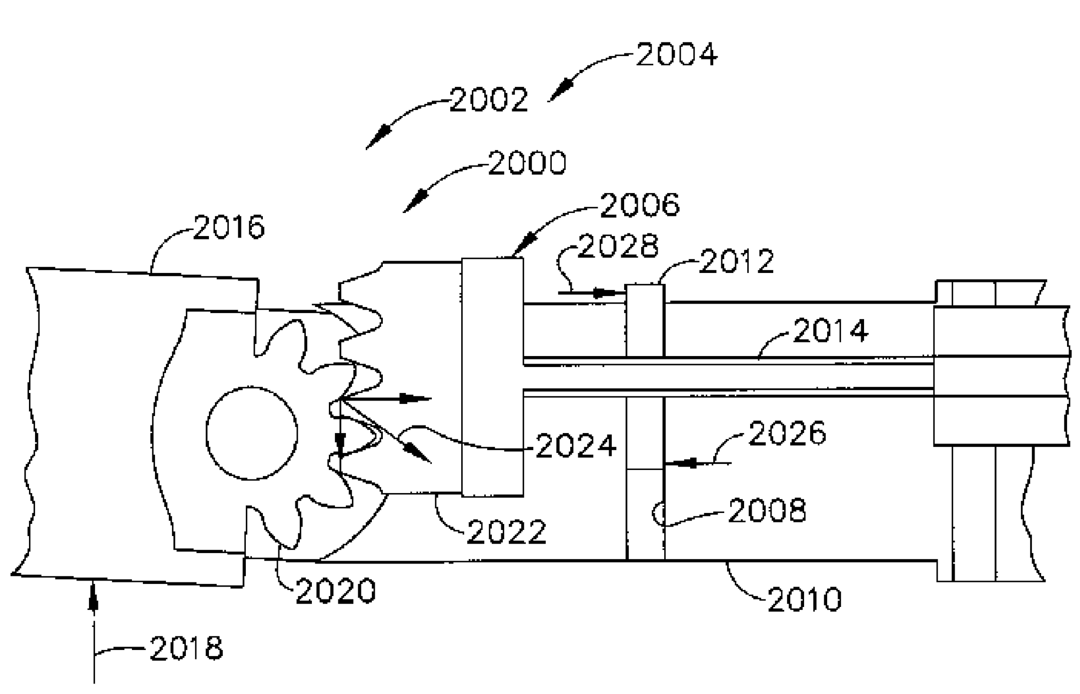
Primary Examiner—Rinaldi I. Rada
Assistant Examiner—Michelle Lopez

(57) **ABSTRACT**

A surgical instrument particularly suited to endoscopic use articulates an end effector by including a laterally sliding member in a proximal portion of a shaft that pivots the end effector to a selected side. Differentially opposing actuating forces (e.g., hydraulic, fluidic, mechanical) act against the laterally sliding member without binding by incorporating guidance mechanisms between the laterally sliding member and a frame of the shaft.

7 Claims, 20 Drawing Sheets





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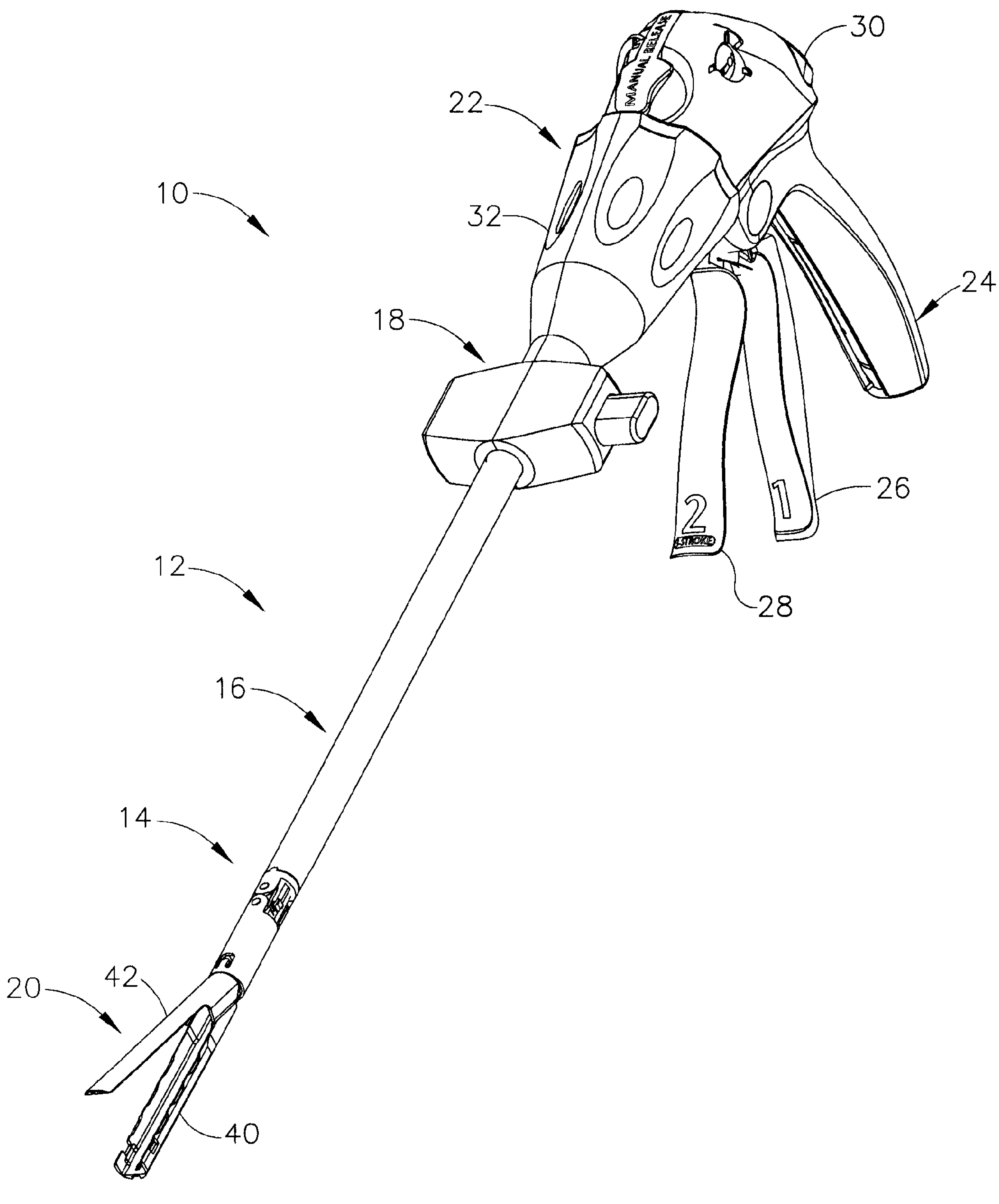

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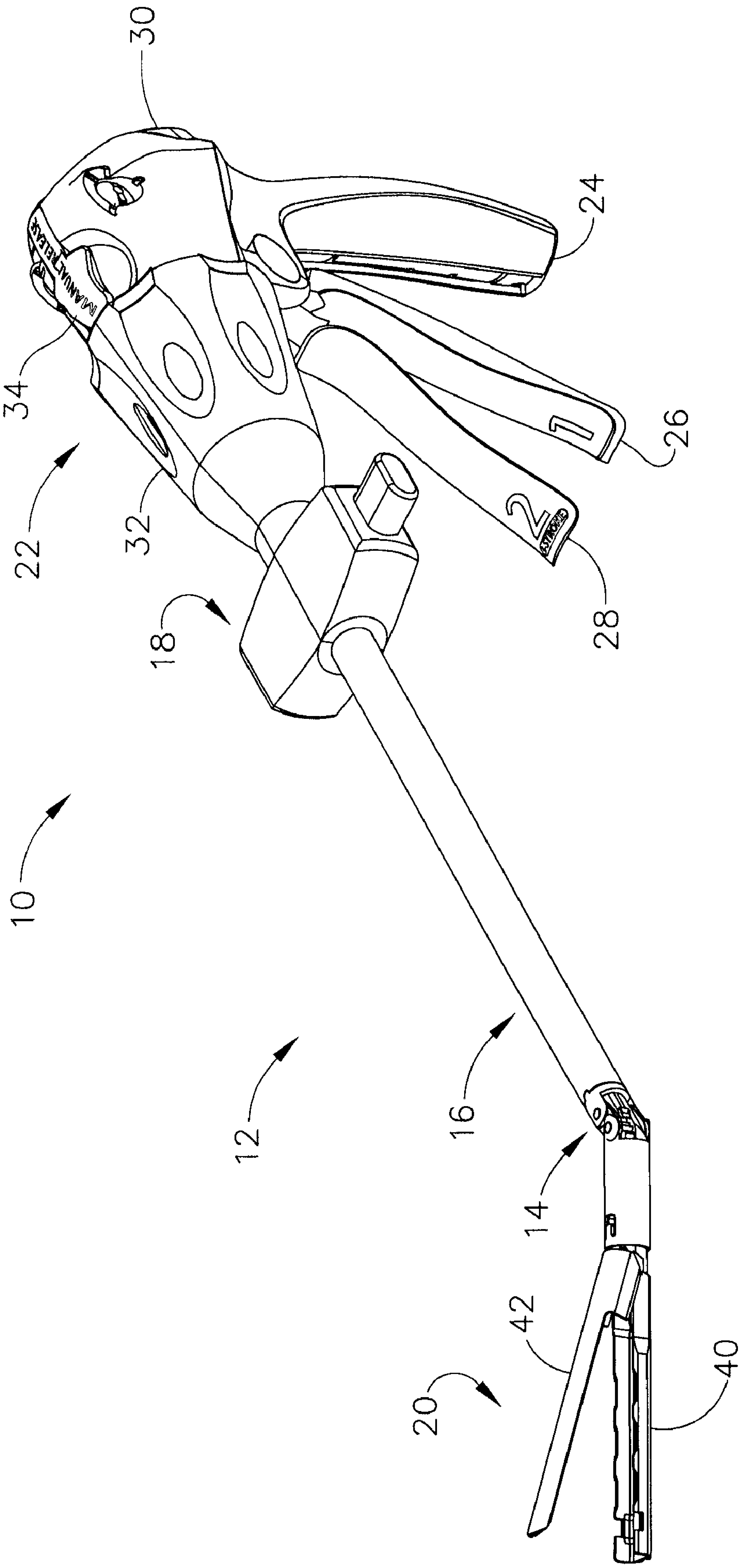

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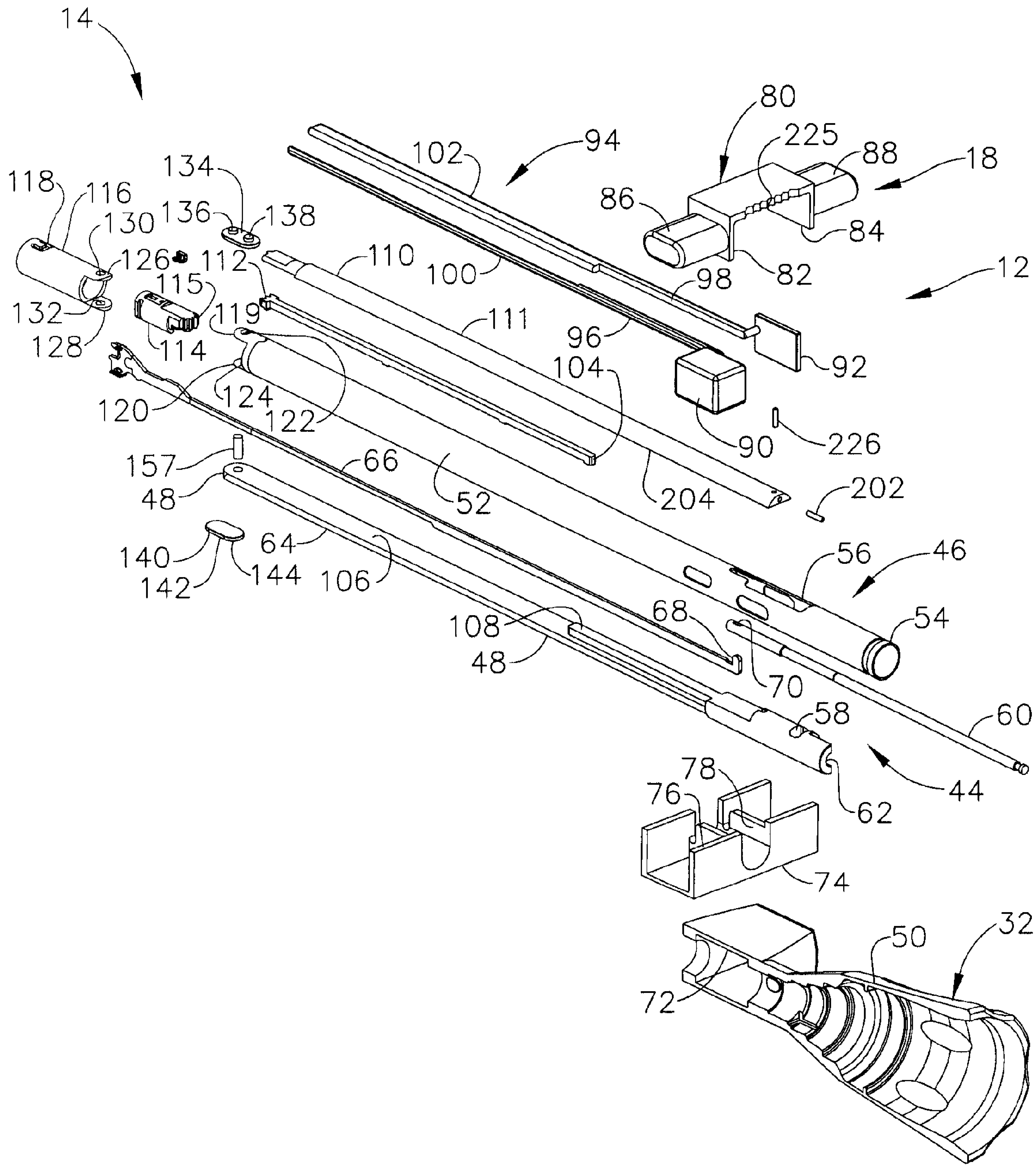
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FIG. 3

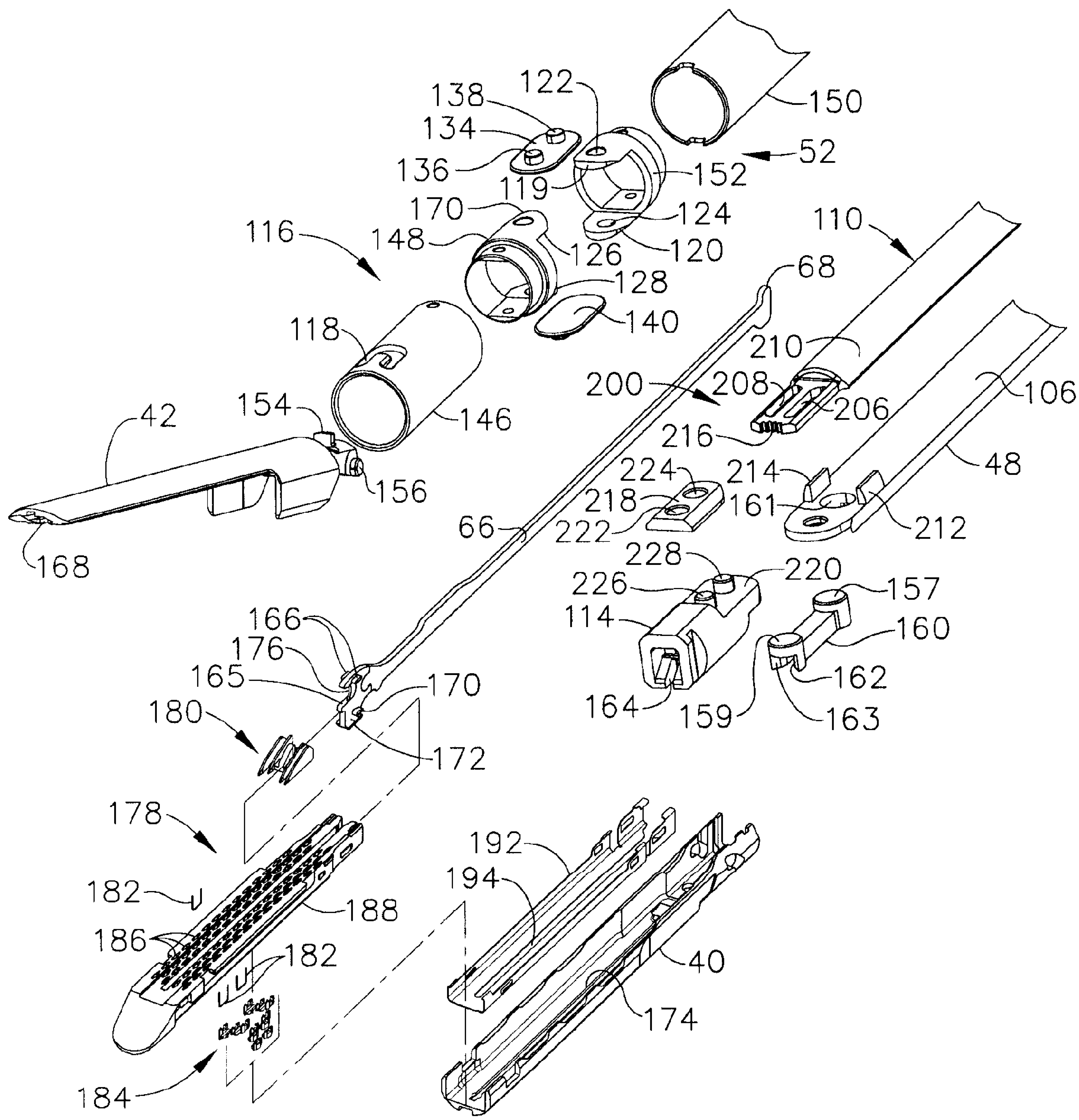
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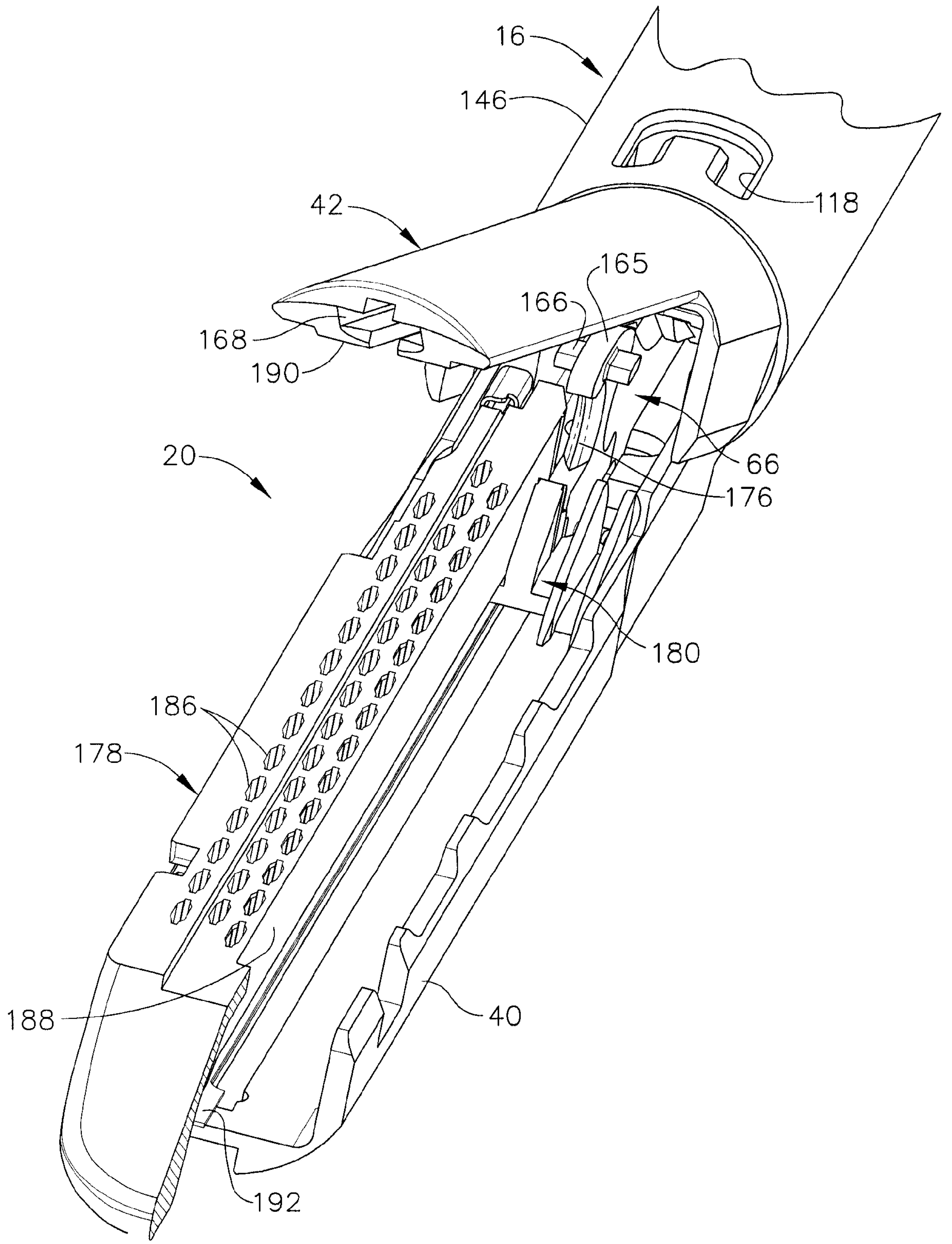
FIG. 4



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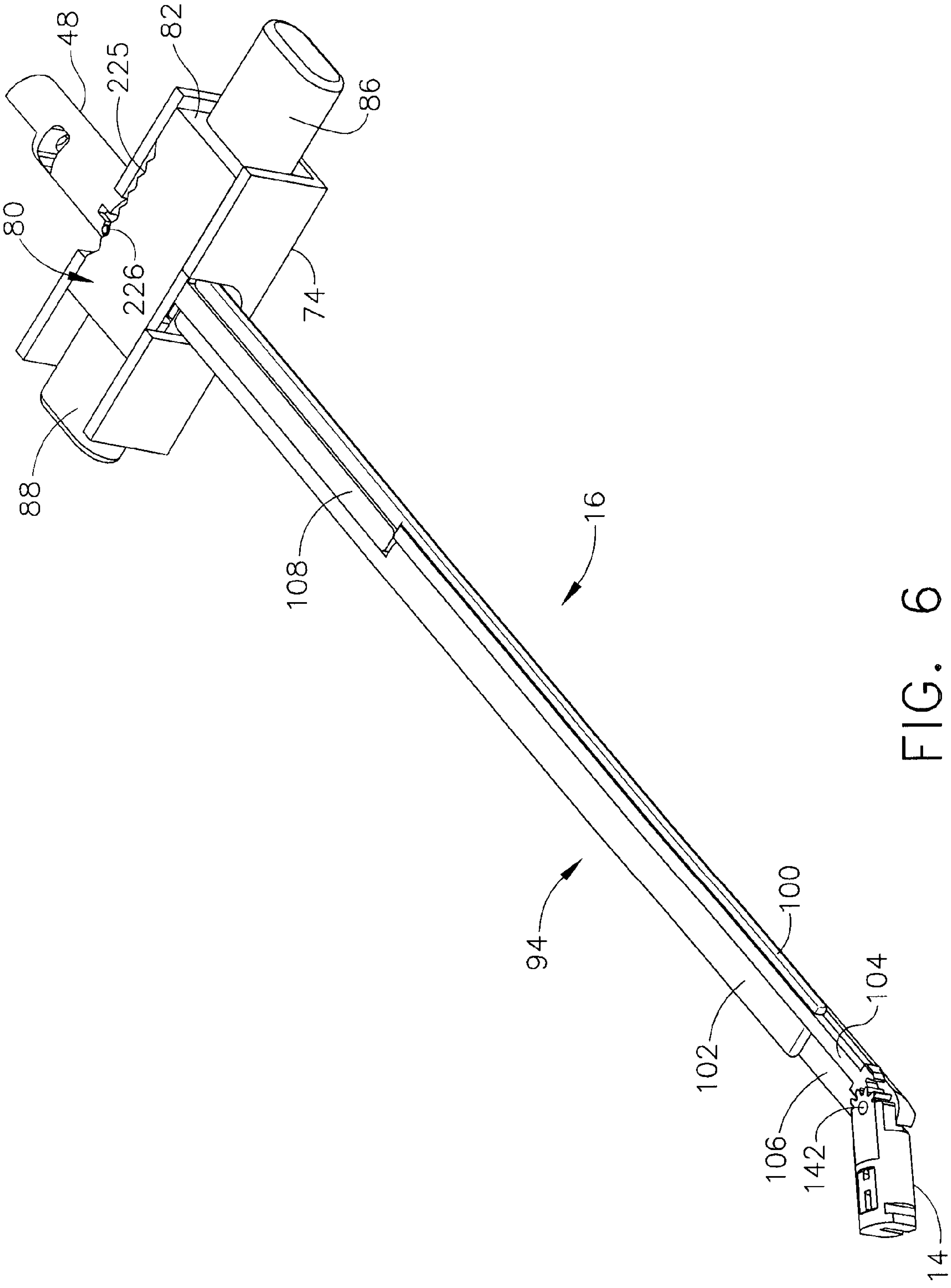

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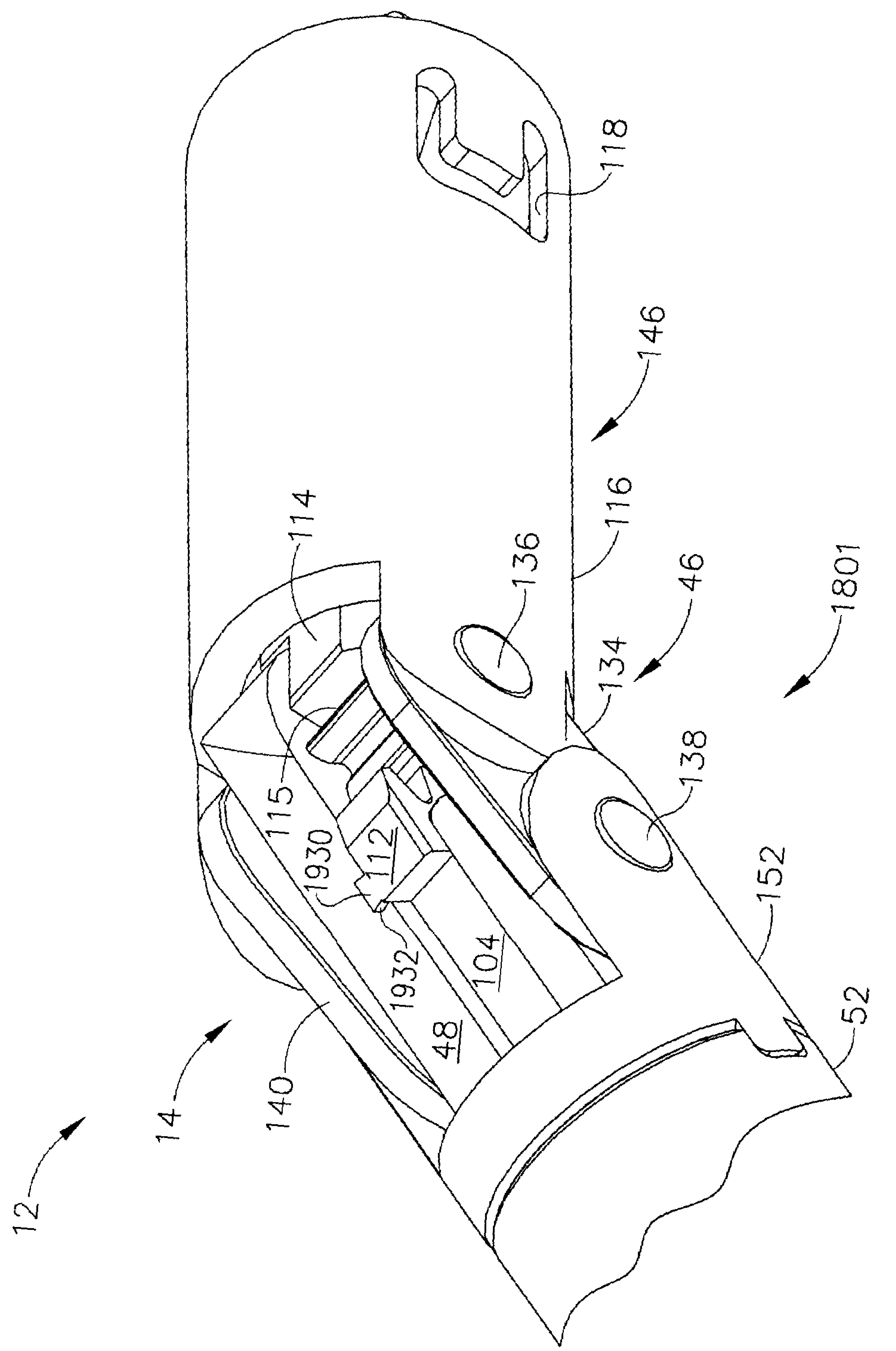

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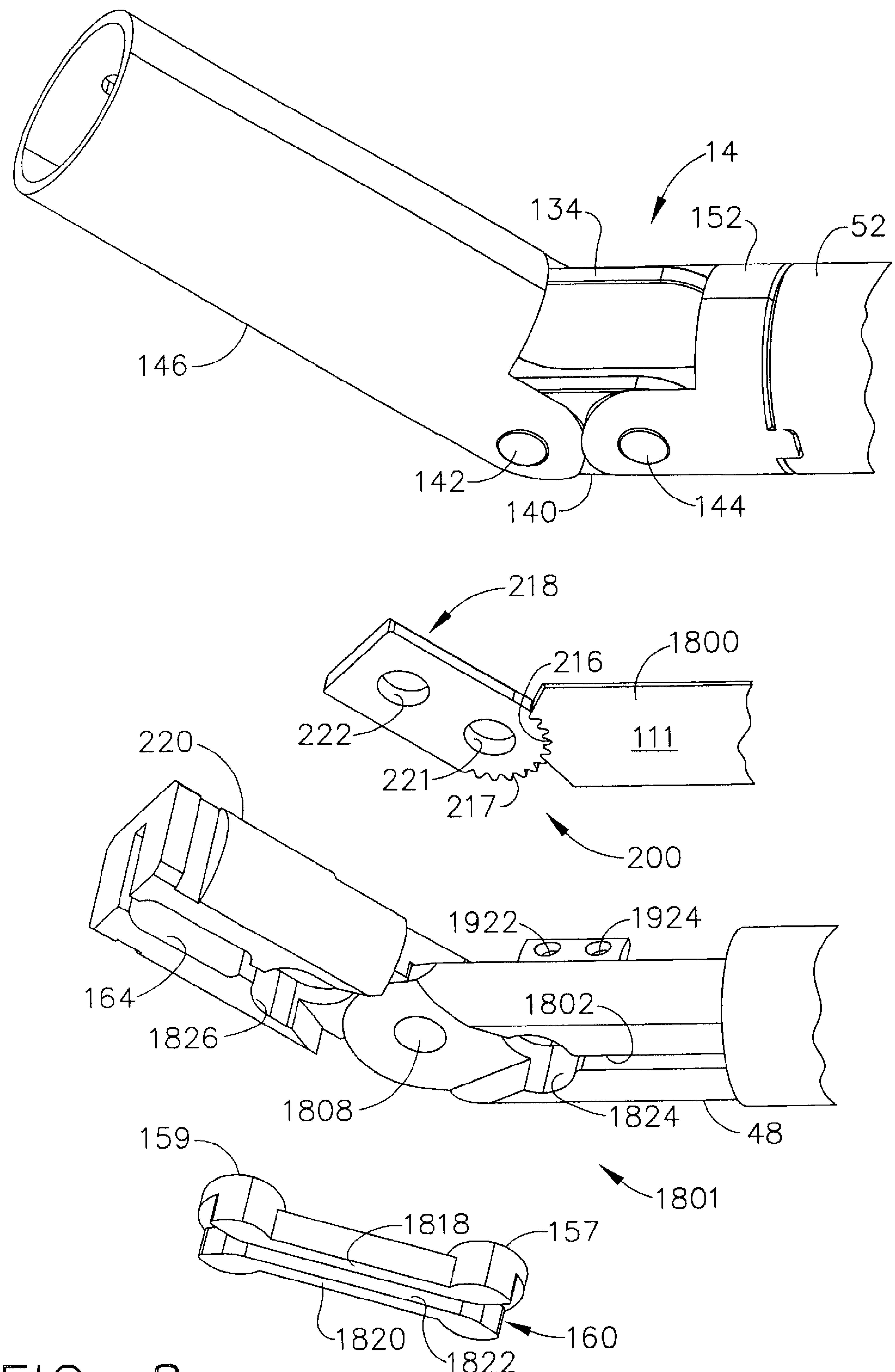
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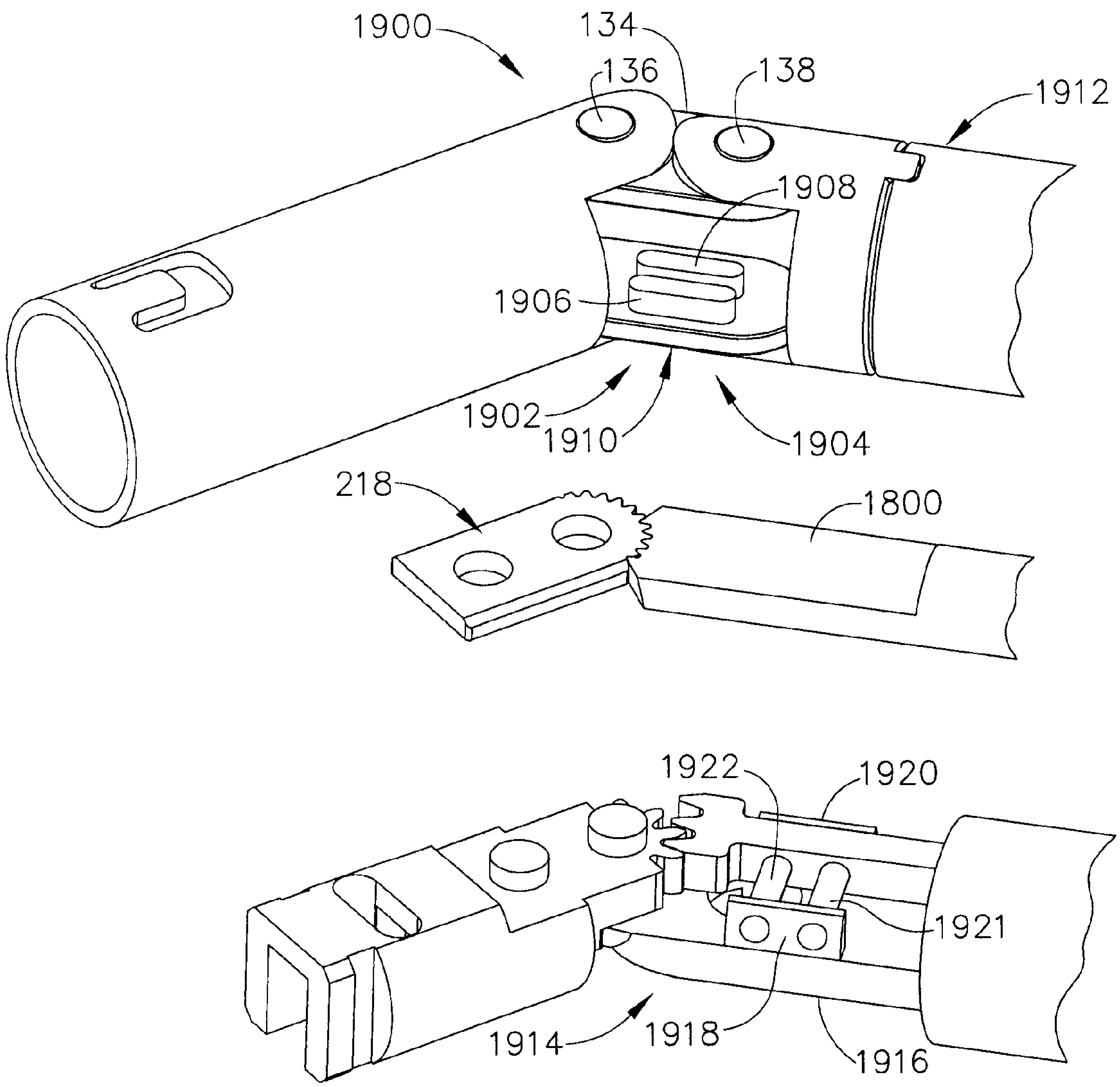
FIG. 8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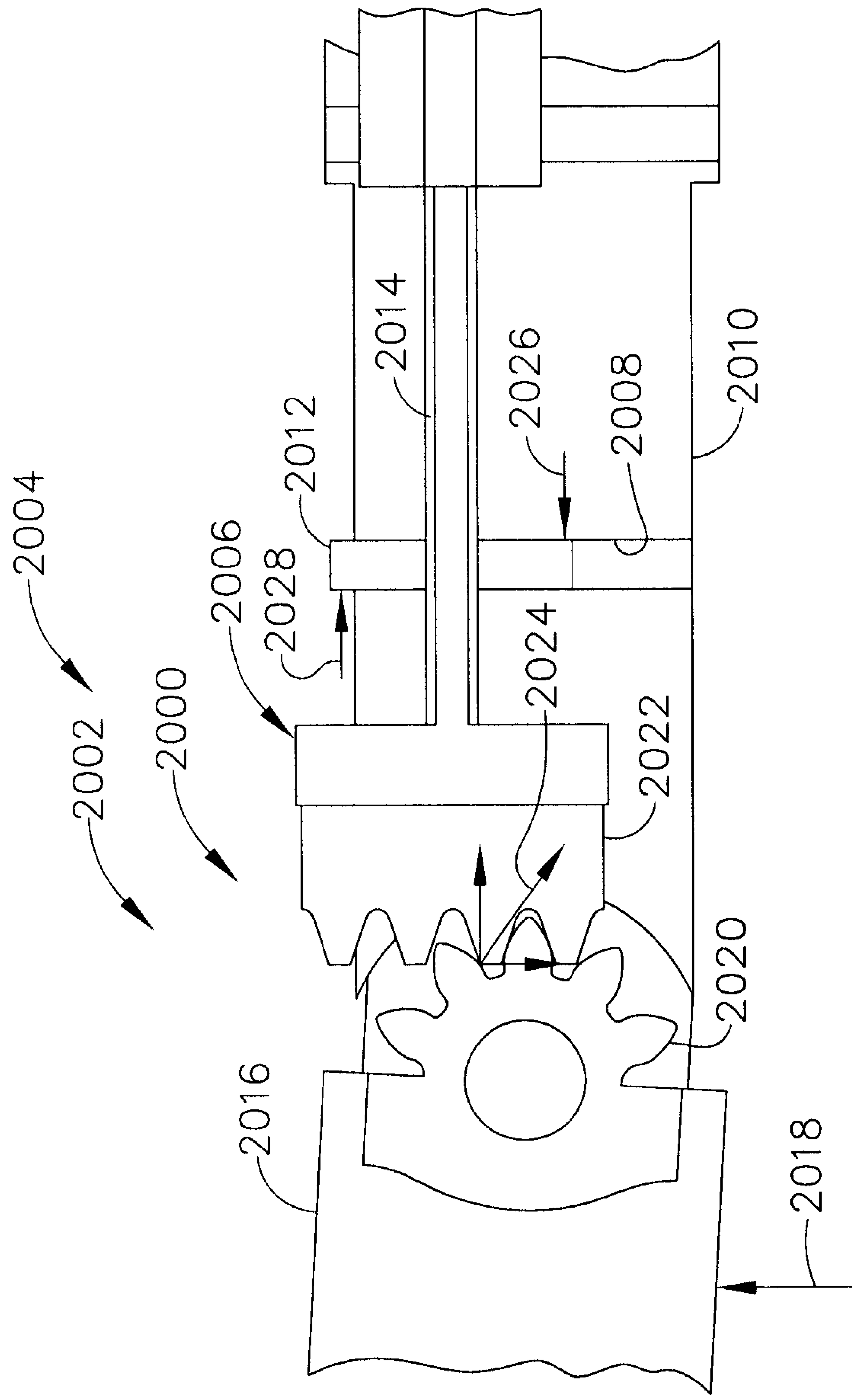
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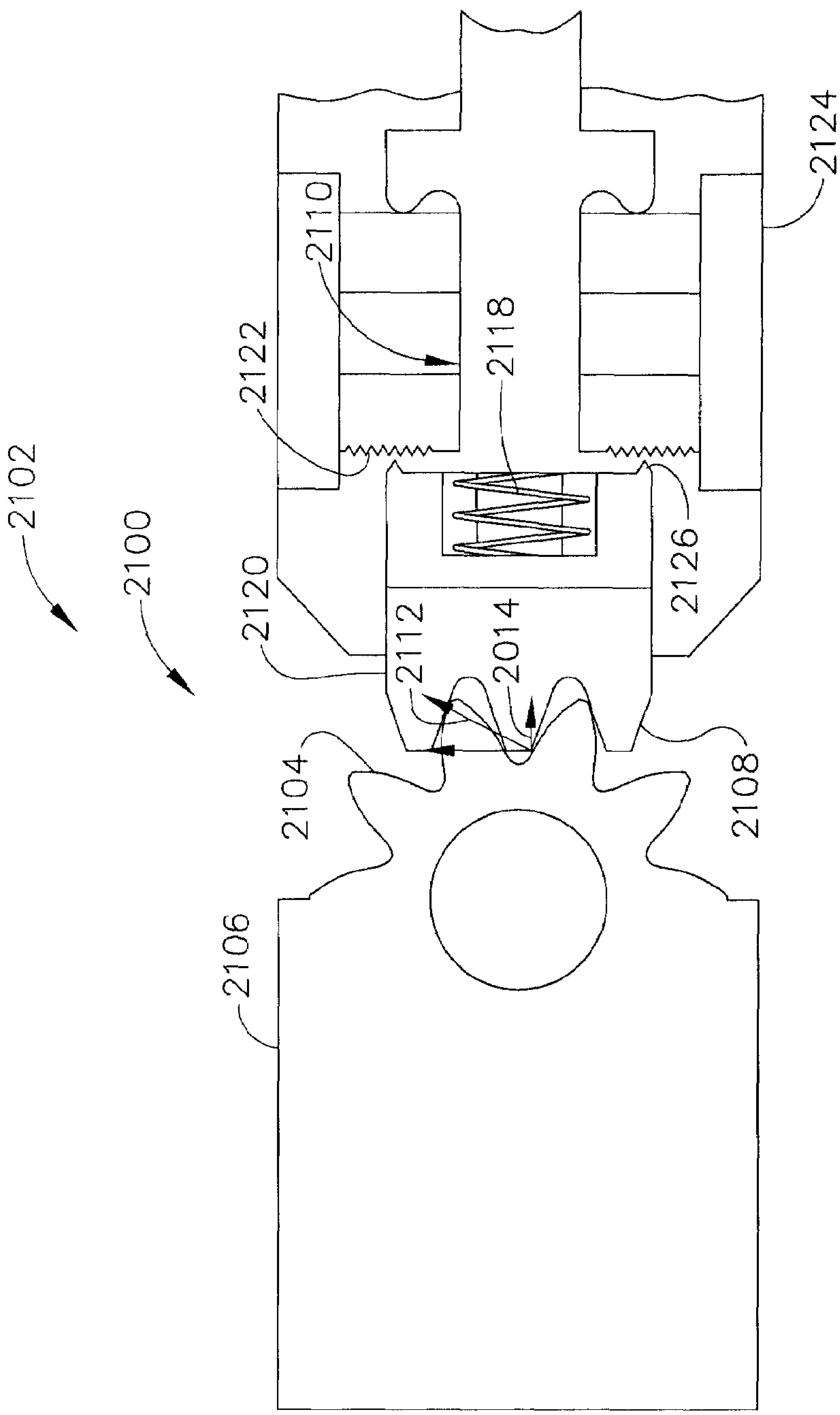
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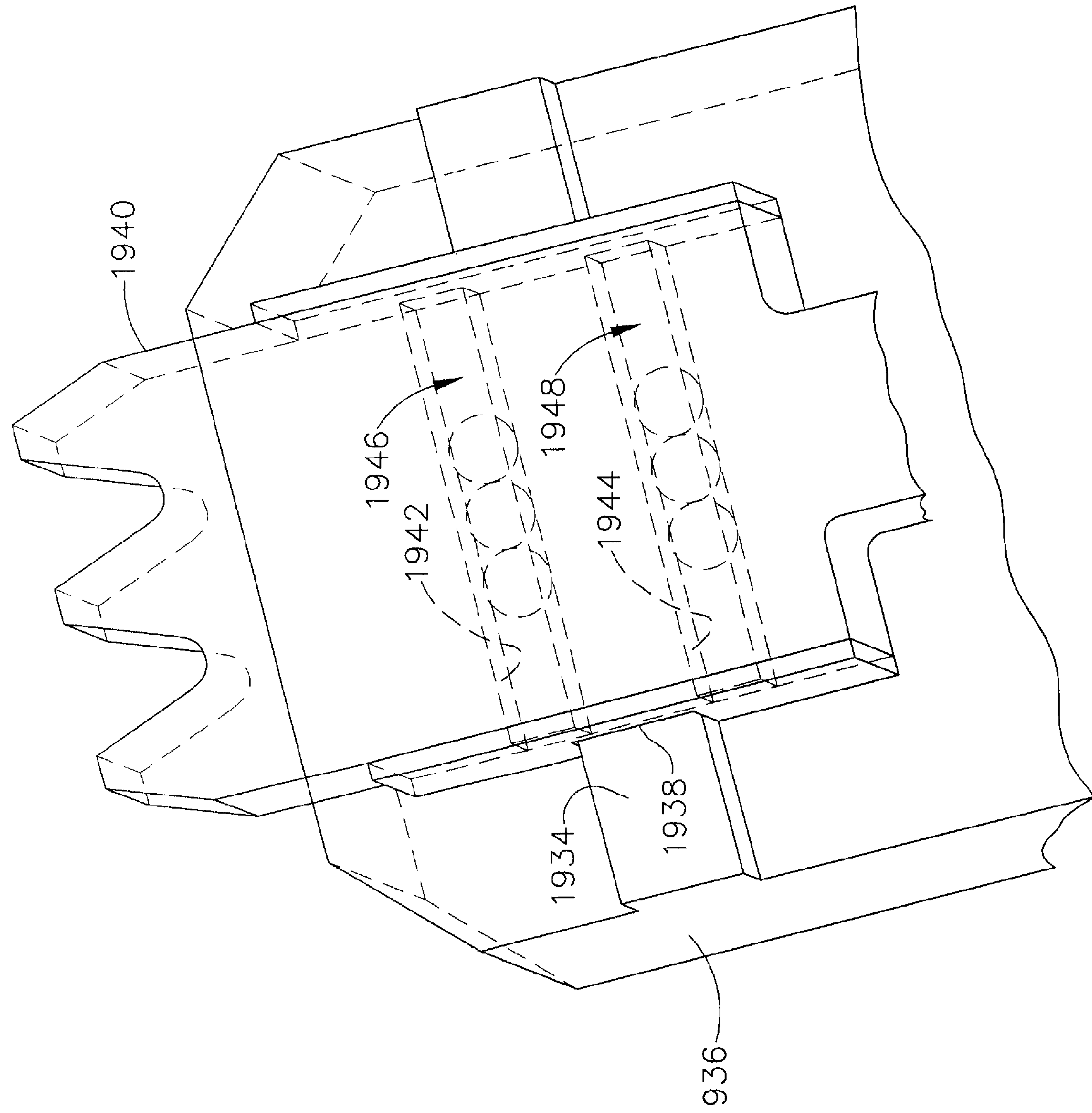

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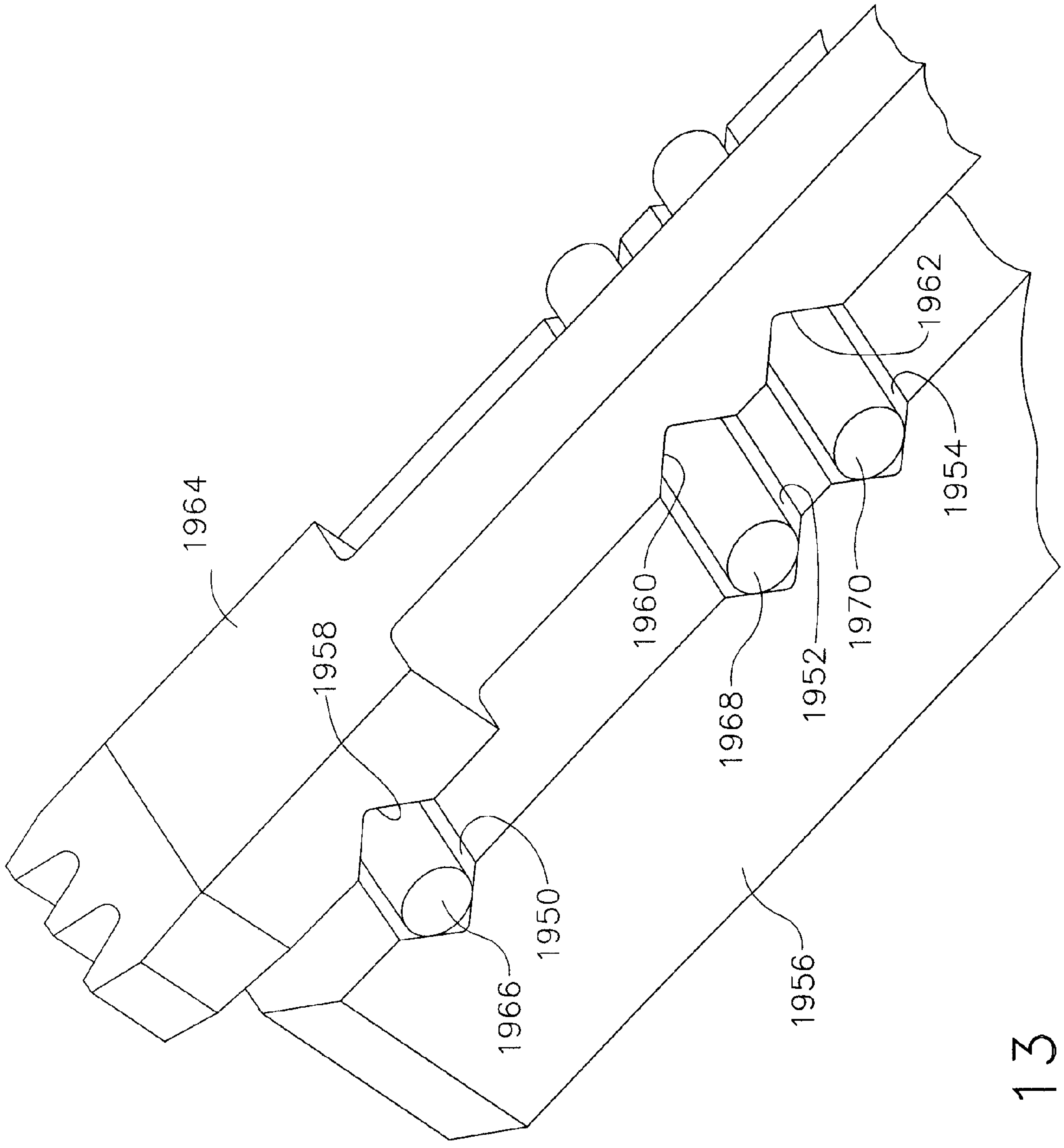

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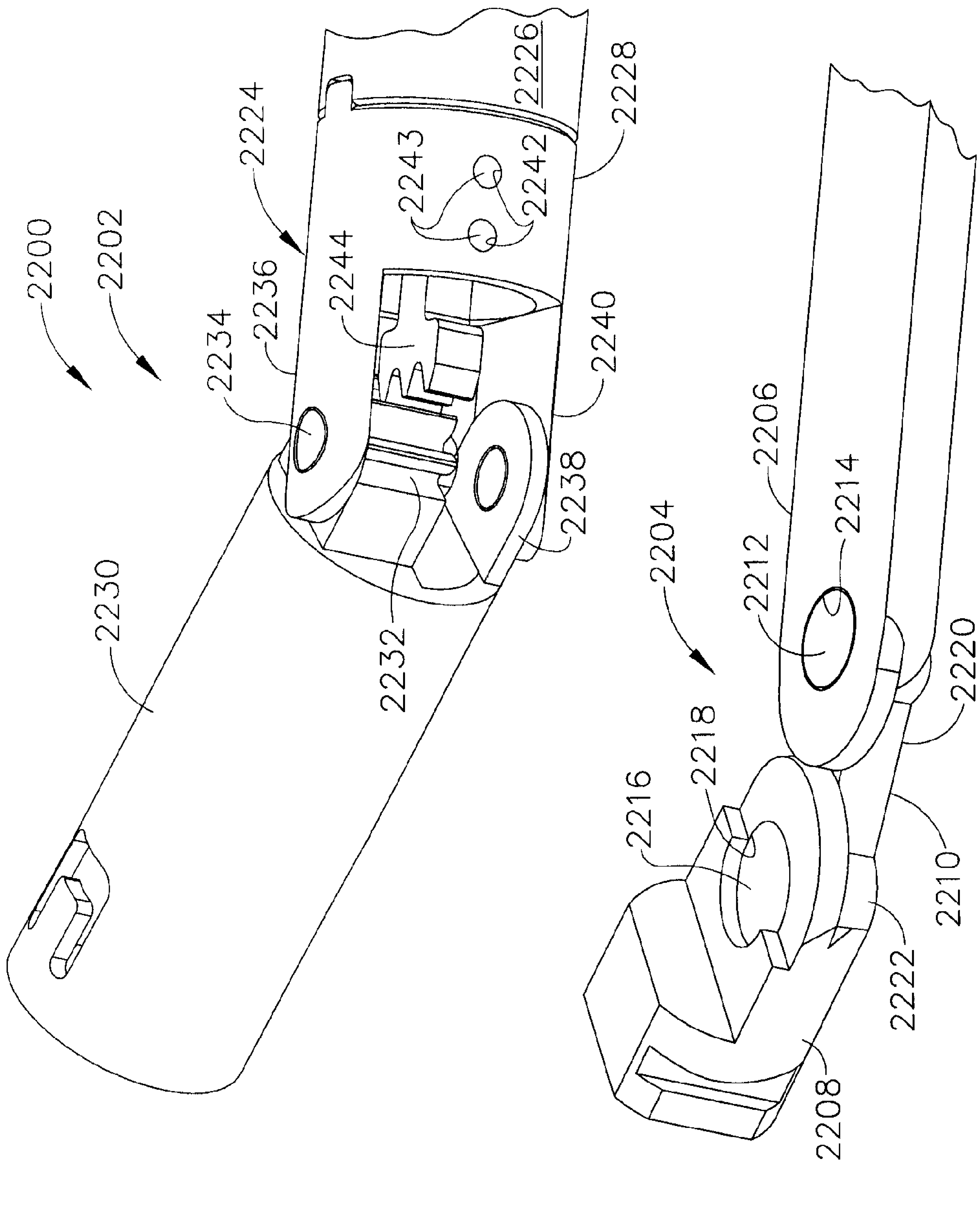
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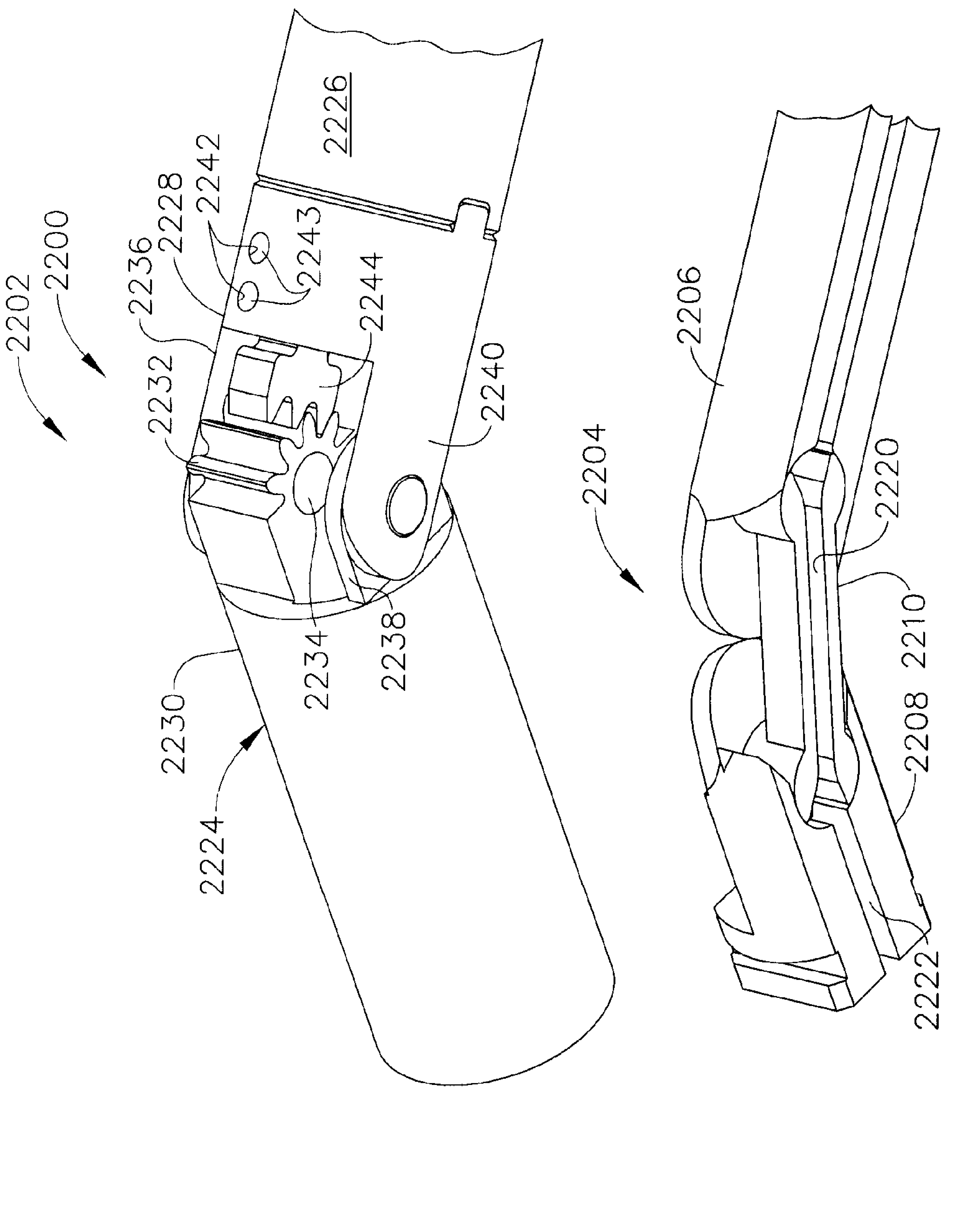
FIG. 14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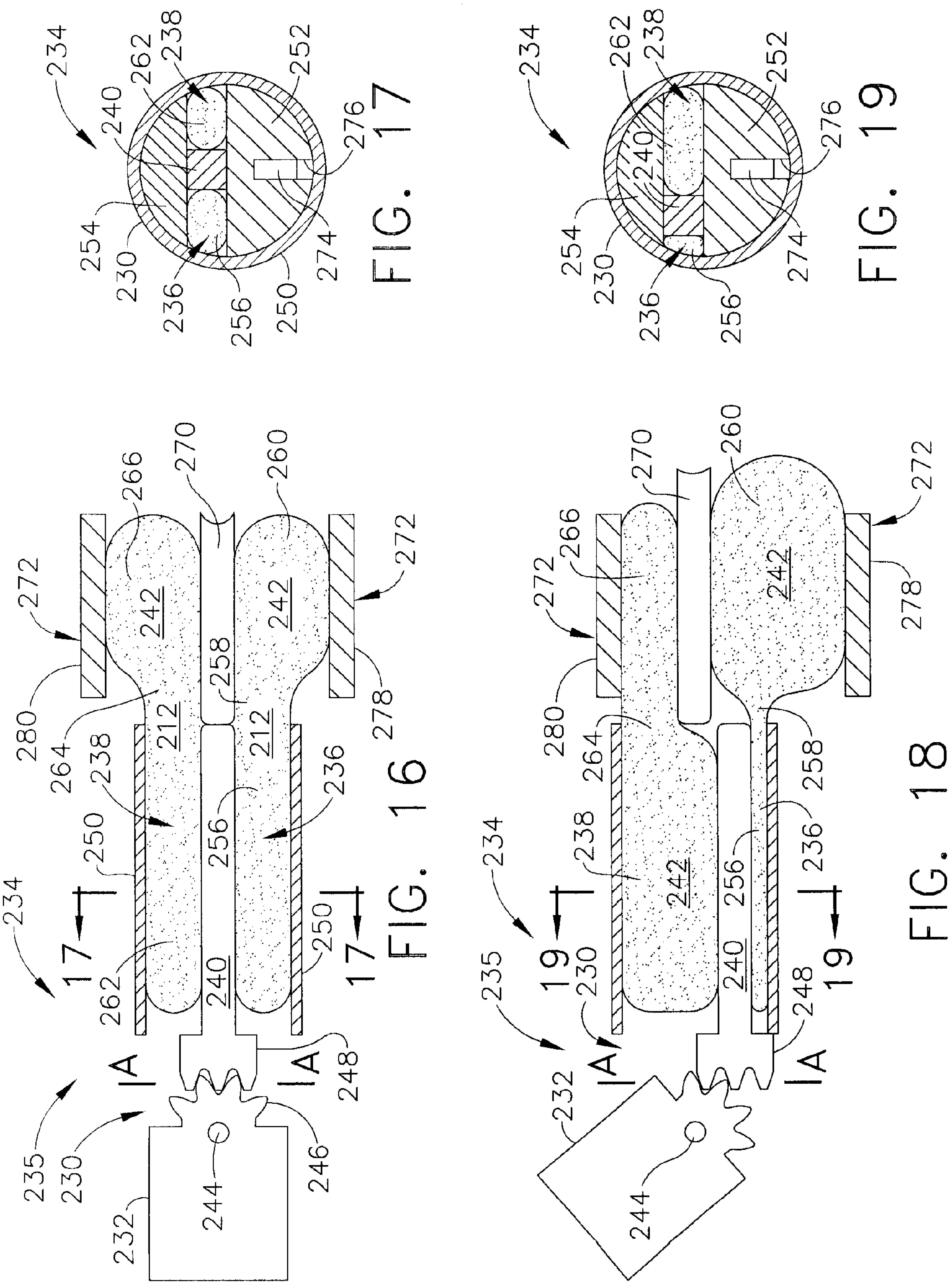

FIG. 16

FIG. 17

FIG. 18

FIG. 19

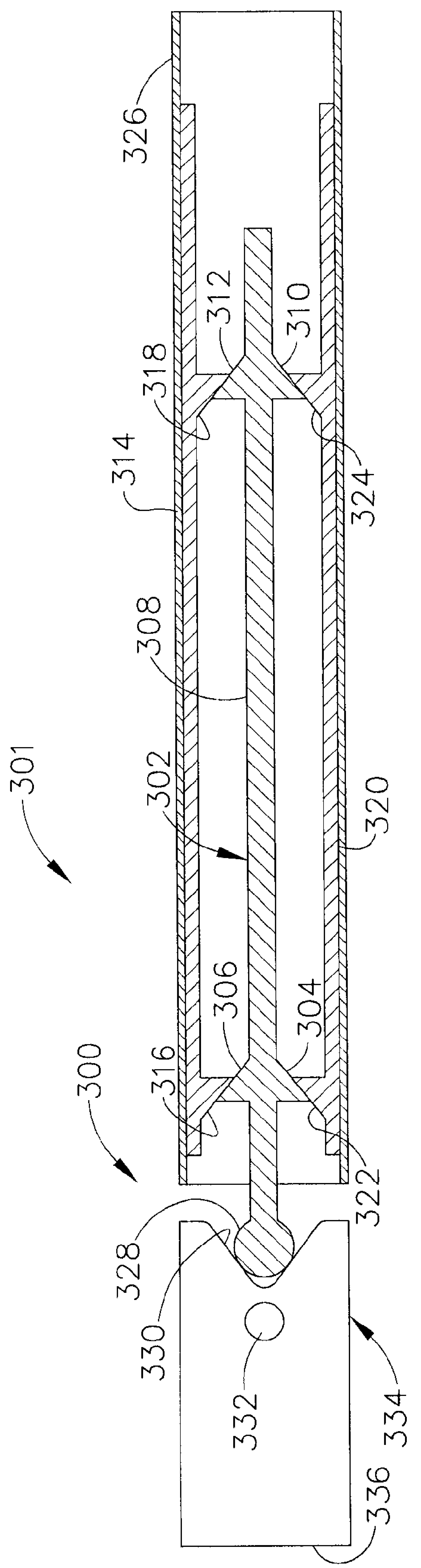
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FIG. 20

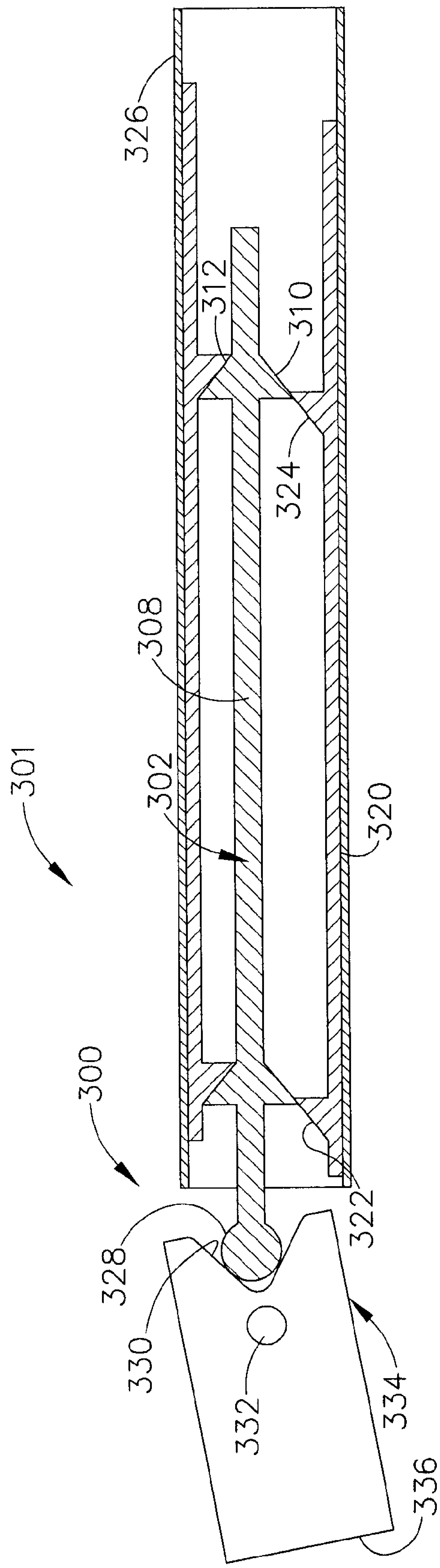
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FIG. 21

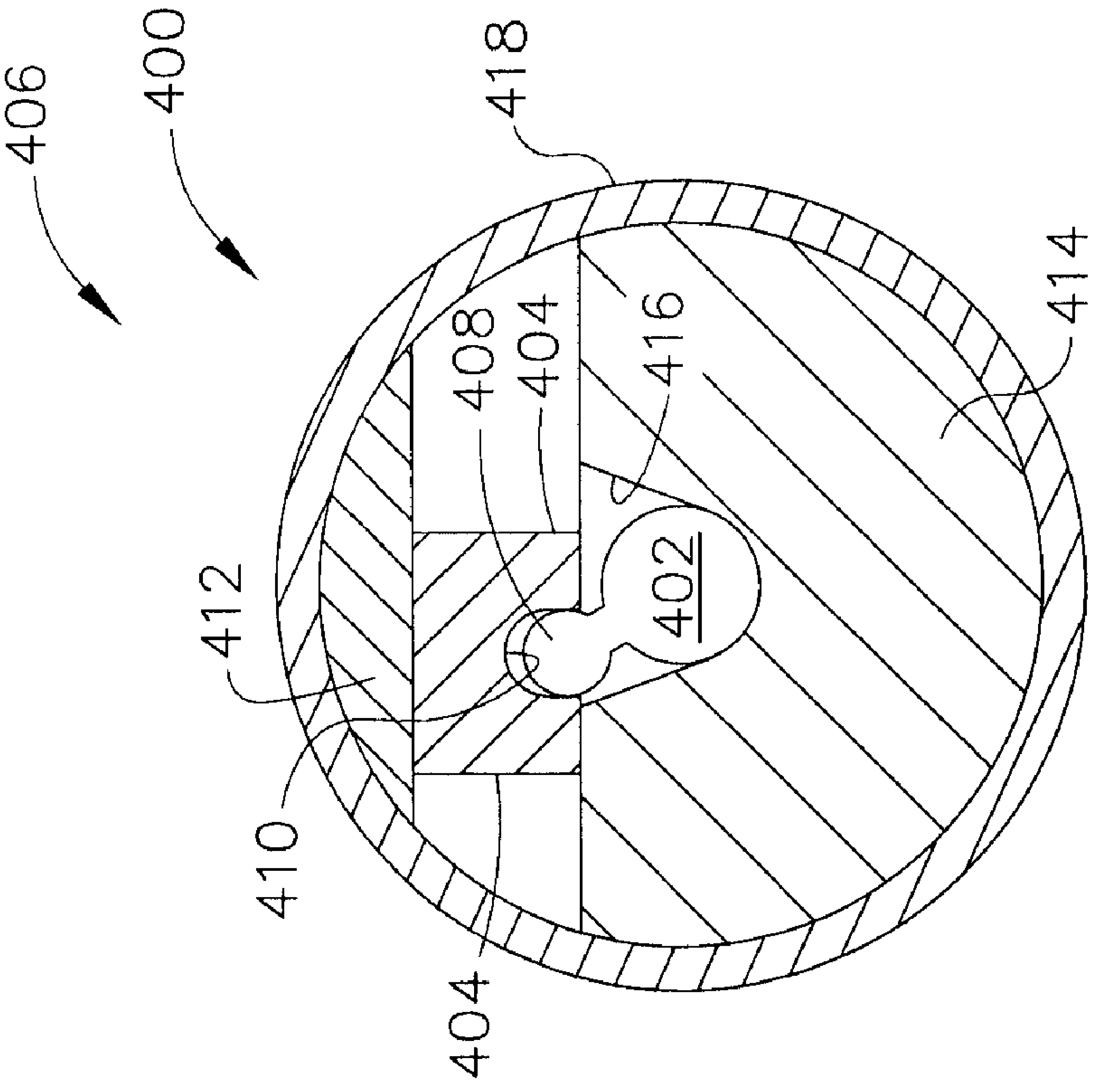
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FIG. 23

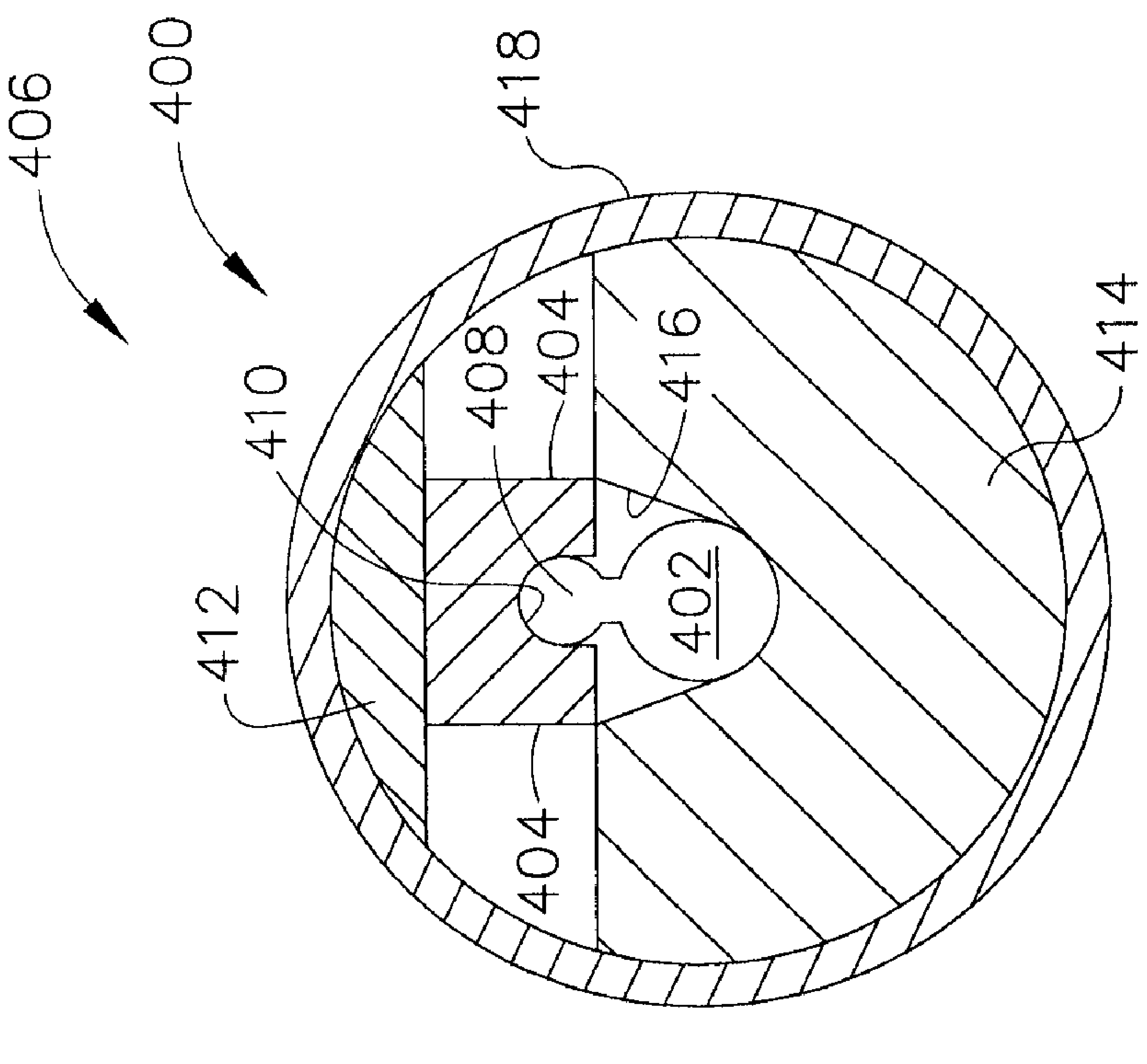
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FIG. 22

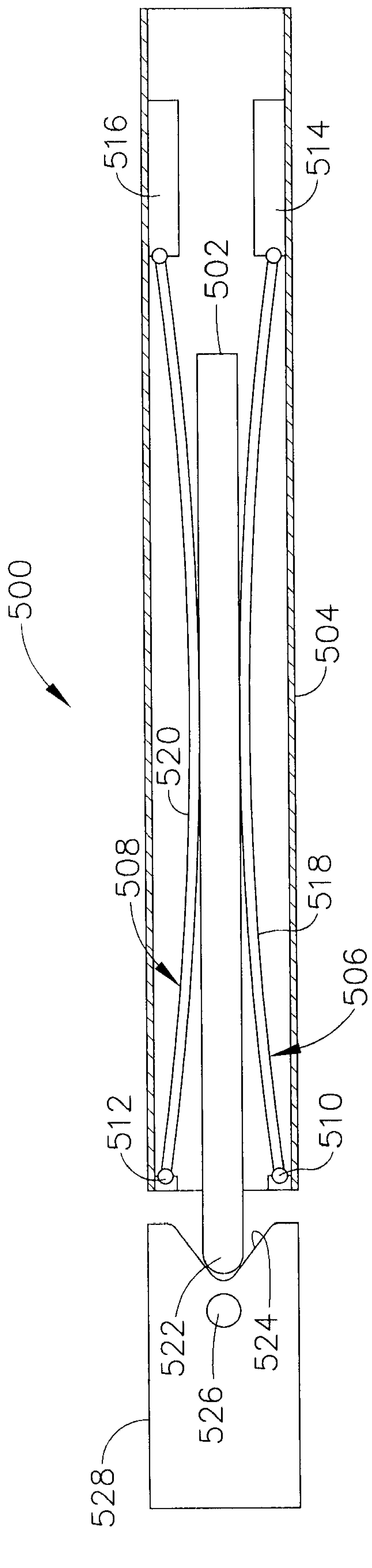
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FIG. 24

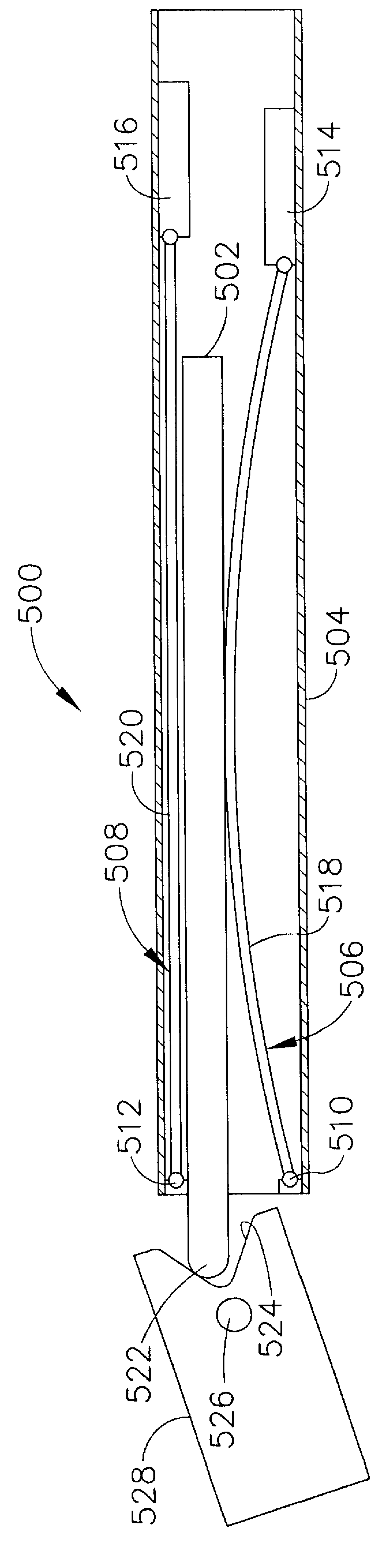
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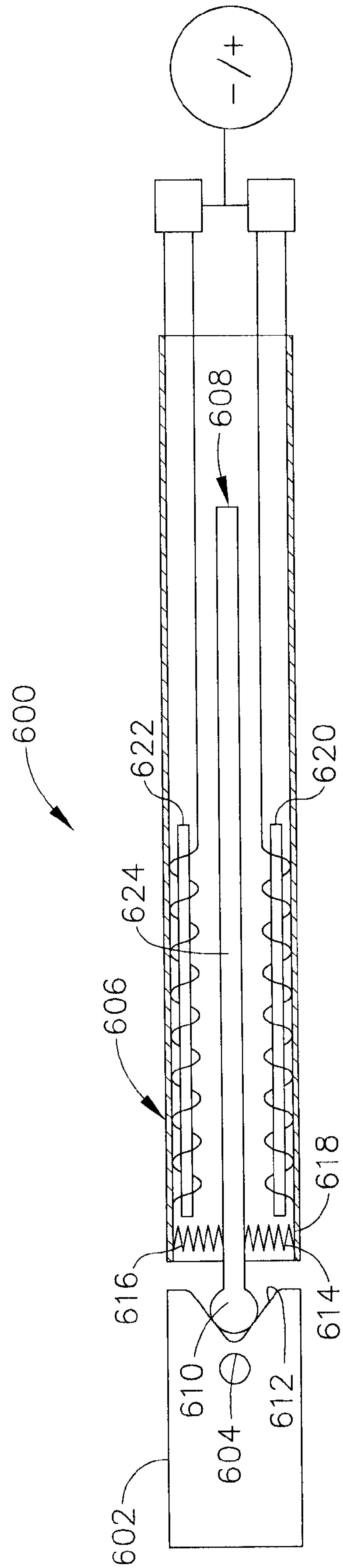
FIG. 25



–/+
608
600
622
620
624
606
618
616
614
610
612
604
602

FIG. 26

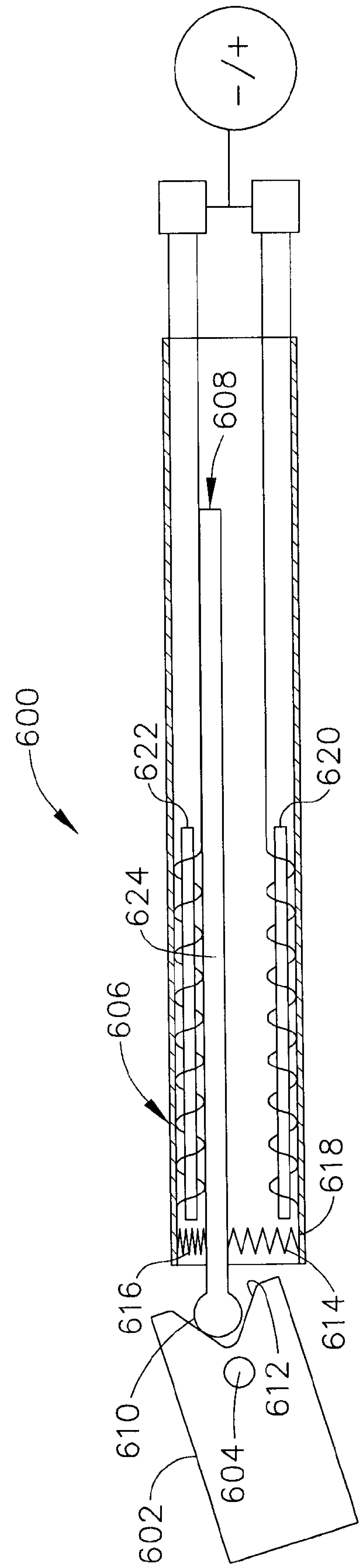


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FIG. 27

SURGICAL INSTRUMENT WITH GUIDED LATERALLY MOVING ARTICULATION MEMBER

CROSS REFERENCE TO RELATED APPLICATIONS

The present invention is a continuation-in-part application of commonly owned U.S. patent application Ser. No. 11/061,908 entitled "SURGICAL INSTRUMENT INCORPORATING A FLUID TRANSFER CONTROLLED ARTICULATION MECHANISM" to Kenneth Wales and Chad Boudreaux filed on Feb. 18, 2005, the disclosure of which is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

The present invention relates in general to surgical instruments that are suitable for endoscopically inserting an end effector (e.g., endocutter, grasper, cutter, staplers, clip applier, access device, drug/gene therapy delivery device, and anenergy device using ultrasound, RF, laser, etc.) to a surgical site, and more particularly to such surgical instruments with an articulating shaft.

BACKGROUND OF THE INVENTION

Endoscopic surgical instruments are often preferred over traditional open surgical devices since a smaller incision tends to reduce the post-operative recovery time and complications. Consequently, significant development has gone into a range of endoscopic surgical instruments that are suitable for precise placement of a distal end effector at a desired surgical site through a cannula of a trocar. These distal end effectors engage the tissue in a number of ways to achieve a diagnostic or therapeutic effect (e.g., endocutter, grasper, cutter, staplers, clip applier, access device, drug/gene therapy delivery device, and energy device using ultrasound, RF, laser, etc.).

Positioning the end effector is constrained by the trocar. Generally, these endoscopic surgical instruments include a long shaft between the end effector and a handle portion manipulated by the clinician. This long shaft enables insertion to a desired depth and rotation about the longitudinal axis of the shaft, thereby positioning the end effector to a degree. With judicious placement of the trocar and use of graspers, for instance, through another trocar, often this amount of positioning is sufficient. Surgical stapling and severing instruments, such as described in U.S. Pat. No. 5,465,895, are an example of an endoscopic surgical instrument that successfully positions an end effector by insertion and rotation.

More recently, U.S. patent Ser. No. 10/443,617, "SURGICAL STAPLING INSTRUMENT INCORPORATING AN E-BEAM FIRING MECHANISM" to Shelton IV et al., filed on 20 May 2003, which is hereby incorporated by reference in its entirety, describes an improved "E-beam" firing bar for severing tissue and actuating staples. Some of the additional advantages include affirmatively spacing the jaws of the end effector, or more specifically a staple applying assembly, even if slightly too much or too little tissue is clamped for optimal staple formation. Moreover, the E-beam firing bar engages the end effector and staple cartridge in a way that enables several beneficial lockouts to be incorporated.

Depending upon the nature of the operation, it may be desirable to further adjust the positioning of the end effector of an endoscopic surgical instrument. In particular, it is often desirable to orient the end effector at an axis transverse to the

longitudinal axis of the shaft of the instrument. The transverse movement of the end effector relative to the instrument shaft is conventionally referred to as "articulation". This is typically accomplished by a pivot (or articulation) joint being placed in the extended shaft just proximal to the staple applying assembly. This allows the surgeon to articulate the staple applying assembly remotely to either side for better surgical placement of the staple lines and easier tissue manipulation and orientation. This articulated positioning permits the clinician to more easily engage tissue in some instances, such as behind an organ. In addition, articulated positioning advantageously allows an endoscope to be positioned behind the end effector without being blocked by the instrument shaft.

Approaches to articulating a surgical stapling and severing instrument tend to be complicated by integrating control of the articulation along with the control of closing the end effector to clamp tissue and fire the end effector (i.e., stapling and severing) within the small diameter constraints of an endoscopic instrument. Generally, the three control motions are all transferred through the shaft as longitudinal translations. For instance, U.S. Pat. No. 5,673,840 discloses an accordion-like articulation mechanism ("flex-neck") that is articulated by selectively drawing back one of two connecting rods through the implement shaft, each rod offset respectively on opposite sides of the shaft centerline. The connecting rods ratchet through a series of discrete positions.

Another example of longitudinal control of an articulation mechanism is U.S. Pat. No. 5,865,361 that includes an articulation link offset from a camming pivot such that pushing or pulling longitudinal translation of the articulation link effects articulation to a respective side. Similarly, U.S. Pat. No. 5,797,537 discloses a similar rod passing through the shaft to effect articulation.

In co-pending and commonly owned U.S. patent application Ser. No. 10/615,973 "SURGICAL INSTRUMENT INCORPORATING AN ARTICULATION MECHANISM HAVING ROTATION ABOUT THE LONGITUDINAL AXIS" to Frederick E. Shelton IV et al, the disclosure of which is hereby incorporated by reference in its entirety, a rotational motion is used to transfer articulation motion as an alternative to a longitudinal motion.

While these mechanically communicated articulation motions have successfully enabled an endoscopic surgical stapling and severing instrument to articulate, development trends pose numerous challenges and barriers to entry into the market. Conflicting design objects include a shaft of as small a diameter as possible to reduce the size of the surgical opening yet with sufficient strength to perform the several motions (e.g., closing, firing, articulation, rotation, etc.). In addition, transferring sufficient force without binding and other frictional problems imposes design constraints that limit desirable features and reliability.

Consequently, a significant need exists for an articulating surgical instrument that incorporates an articulation mechanism that employs an articulation force that may be incorporated within the close confines thereof without interfering with the firing and closing motions.

BRIEF SUMMARY OF THE INVENTION

The invention overcomes the above-noted and other deficiencies of the prior art by providing a surgical instrument having an articulating shaft attached between a handle and an end effector that uses a laterally sliding member in the proximal portion of the shaft that acts against a pivoting feature of the end effector. Laterally moving actuators on opposing sides of the laterally sliding member control the pivoting to each side. This laterally moving member presents a large longitudinal surface area to act upon. Advantageously, a frame of the shaft that support moving components therein includes a lateral guide mechanism that engages the lateral sliding member, thus avoiding binding that may otherwise impair performance.

In one aspect of the invention, a surgical instrument includes a proximal portion that is manipulated external to a patient to position an attached elongate shaft and end effector to a desired surgical site inside of the patient. An articulation joint attaches the end effector to the elongate shaft to give further clinical flexibility in reaching tissue at a desired angle. An articulation control, which is attached to the proximal portion, transfers a differential longitudinal motion down the shaft to cooperatively act upon respective sides of the laterally sliding member. A lateral channel formed in one of the frame or lateral sliding member is engaged by a corresponding lateral track formed in the other. Thereby, the lateral sliding member is prevented from being actuated in an angled orientation other than aligned with the longitudinal axis of the shaft.

In another aspect of the invention, expansive and compressive bladders oppose each side of the laterally sliding member.

These and other objects and advantages of the present invention shall be made apparent from the accompanying drawings and the description thereof.

BRIEF DESCRIPTION OF THE FIGURES

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention, and, together with the general description of the invention given above and the detailed description of the embodiments given below, serve to explain the principles of the present invention.

FIG. **1** is a front top perspective view of a surgical stapling and severing instrument shown with an open end effector, or staple applying assembly, and with the staple cartridge removed.

FIG. **2** is a front top perspective view of the surgical stapling and severing instrument of FIG. **1** with an articulation mechanism actuated by a fluidic actuation control.

FIG. **3** is a perspective disassembled view of an elongate shaft and articulation mechanism of the surgical stapling and severing instrument of FIG. **1**.

FIG. **4** is a perspective disassembled view of distal portions of an implement portion of the surgical stapling and severing instrument of FIG. **1**, including the staple applying assembly and articulation mechanism.

FIG. **5** is a top perspective view of the staple applying assembly of FIGS. **1** and **4** with a lateral half of a staple cartridge removed to expose components driven by a firing motion.

FIG. **6** is a front perspective view of an implement portion of the surgical instrument of FIG. **1** with a double pivot closure sleeve assembly and end effector removed to expose a single pivot frame ground articulated by a fluidic articulation mechanism.

FIG. **7** is perspective detail view of an alternative articulation joint for the surgical instrument of FIG. **1** depicting a double pivoting closure sleeve assembly at a proximal position with a single pivot frame ground.

FIG. **8** is a bottom right perspective exploded view of the alternative articulation joint of FIG. **7** including a double pivoting fixed-wall dog bone link and a frame ground incorporating rail guides for a lateral moving member (T-bar).

FIG. **9** is top left perspective exploded view of a further alternative articulation joint for the surgical instrument of FIG. **1**, including an alternate solid wall support plate mechanism incorporated into a lower double pivot link to support a firing bar and includes a rail guided laterally moving member (T-bar).

FIG. **10** is a top diagrammatic view of an alternate articulation locking mechanism for the surgical instrument of FIG. **1** with a closure sleeve assembly removed to expose a backloading disengaged T-bar for automatic articulation lock engagement and disengagement.

FIG. **11** is a top diagrammatic view of an additional alternative articulation mechanism for the surgical instrument of FIG. **1**, a spring biased rack on a T-bar with locking features that engage due to backloading from an end effector.

FIG. **12** is an alternative T-bar and frame ground incorporating lateral guidance for the surgical instrument of FIG. **1**.

FIG. **13** is yet an additional alternative T-bar and frame ground incorporating lateral guidance for the surgical instrument of FIG. **1**.

FIG. **14** is a left top perspective disassembled view of an alternative articulation mechanism including a double pivoting frame assembly and single pivoting closure sleeve assembly for the surgical instrument of FIG. **1**.

FIG. **15** is a left bottom perspective view of the alternative articulation mechanism of FIG. **14**.

FIG. **16** is a diagram of a laterally moving fluidic articulation mechanism with rack and gear segment pivoting depicted in a nonarticulated state.

FIG. **17** is cross section front view in elevation of the fluidic articulation mechanism of FIG. **16** taken along lines **17**—**17**.

FIG. **18** is a diagram of the laterally moving fluidic articulation mechanism with a rack and gear segment pivoting depicted in an articulated state.

FIG. **19** is cross section front view in elevation of the fluidic articulation mechanism of FIG. **18** taken along lines **19**—**19**.

FIG. **20** is a top diagrammatic view of a surgical instrument articulated by at least one longitudinally moving member that laterally cams a slide bar, which in turn articulates an end effector.

FIG. **21** is a top diagrammatic view of the surgical instrument of FIG. **20** in an articulated state.

FIG. **22** is front cross section view in elevation of an alternative rotary link mechanical control system for a surgical instrument of FIG. **16** or **20** for laterally translating respectively a T-bar or slide bar, depicted in an unarticulated state.

FIG. **23** is a front cross section view in elevation of the alternative rotary link mechanical control system of FIG. **22** in an articulated state.

FIG. **24** is a top diagrammatic view of a surgical instrument having a slide bar laterally positioned by a pair of buckling members, each with a longitudinally adjustable proximal endpoint, to articulate an end effector.

FIG. **25** is a top diagrammatic view of the surgical instrument of FIG. **24** depicted in an articulated state.

FIG. **26** is a top diagrammatic view of a surgical instrument having an electromagnetic lateral articulation control mechanism.

FIG. **27** is a top diagrammatic view of the surgical instrument of FIG. **26** in an articulated state.

DETAILED DESCRIPTION OF THE INVENTION

Overview of Articulating Shaft

Turning to the Drawings, wherein like numerals denote like components throughout the several views, FIG. **1** depicts a surgical instrument, which in the illustrative versions is more particularly a surgical stapling and severing instrument **10**, that is capable of practicing the unique benefits of the present invention. In particular, the surgical stapling and severing instrument **10** is sized for insertion, in a nonarticulated state as depicted in FIG. **1**, through a trocar cannula passageway to a surgical site in a patient (not shown) for performing a surgical procedure. Once an implement portion **12** is inserted through a cannula passageway, an articulation mechanism **14** incorporated into a distal portion of an elongate shaft **16** of the implement portion **12** may be remotely articulated, as depicted in FIG. **2**, by an articulation control **18**. An end effector, depicted in the illustrative version as a staple applying assembly **20**, is distally attached to the articulation mechanism **14**. Thus, remotely articulating the articulation mechanism **14** thereby articulates the staple applying assembly **20** from a longitudinal axis of the elongate shaft **16**. Such an angled position may have advantages in approaching tissue from a desired angle for severing and stapling, approaching tissue otherwise obstructed by other organs and tissue, and/or allowing an endoscope to be positioned behind and aligned with the staple applying assembly **20** for confirming placement.

Handle

The surgical and stapling and severing instrument **10** includes a handle portion **22** proximally connected to the implement portion **12** for providing positioning, articulation, closure and firing motions thereto. The handle portion **22** includes a pistol grip **24** toward which a closure trigger **26** is pivotally and proximally drawn by the clinician to cause clamping, or closing, of the staple applying assembly **20**. A firing trigger **28** is farther outboard of the closure trigger **26** and is pivotally drawn by the clinician to cause the stapling and severing of tissue clamped in the staple applying assembly **20**. Thereafter, a closure release button **30** is depressed to release the clamped closure trigger **26**, and thus the severed and stapled ends of the clamped tissue. The handle portion **22** also includes a rotation knob **32** coupled for movement with the elongate shaft **16** to rotate the shaft **16** and the articulated staple applying assembly **20** about the longitudinal axis of the shaft **16**. The handle portion **22** also includes a firing retraction handle **34** to assist in retracting a firing mechanism (not depicted in FIGS. **1**–**2**) should binding occur, so that opening of the staple applying assembly **20** may occur thereafter.

It will be appreciated that the terms "proximal" and "distal" are used herein with reference to a clinician gripping a handle of an instrument. Thus, the surgical stapling assembly **20** is distal with respect to the more proximal handle portion **22**. It will be further appreciated that for convenience and clarity, spatial terms such as "vertical" and "horizontal" are used herein with respect to the drawings. However, surgical instruments are used in many orientations and positions, and these terms are not intended to be limiting and absolute.

An illustrative multi-stroke handle portion **22** for the surgical stapling and severing instrument **10** of FIGS. **1**–**2** is described in greater detail in the co-pending and commonly-owned U.S. patent application entitled "SURGICAL STAPLING INSTRUMENT INCORPORATING A MULTI-STROKE FIRING POSITION INDICATOR AND RETRACTION MECHANISM" to Swayze and Shelton IV, Ser. No. 10/674,026, the disclosure of which is hereby incorporated by reference in its entirety, with additional features and variation as described herein. While a multi-stroke handle portion **22** advantageously supports applications with high firing forces over a long distance, applications consistent with the present invention may incorporate a single firing stroke, such as described in co-pending and commonly owned U.S. patent application "SURGICAL STAPLING INSTRUMENT HAVING SEPARATE DISTINCT CLOSING AND FIRING SYSTEMS" to Frederick E. Shelton IV, Michael E. Setser, and Brian J. Hemmelgam, Ser. No. 10/441,632, the disclosure of which is hereby incorporated by reference in its entirety.

Implement Portion (Articulating Elongate Shaft and Staple Applying Assembly)

In FIGS. **3**–**5**, the implement portion **12** advantageously incorporates the multiple actuation motions of longitudinal rotation, articulation, closure and firing within a small diameter suitable for endoscopic and laparoscopic procedures. The staple applying assembly **20** ("end effector") has a pair of pivotally opposed jaws, depicted as an elongate channel **40** with a pivotally attached anvil **42** (FIGS. **1**–**2**, **4**–**5**). Closure and clamping of the anvil **42** to the elongate channel **40** is achieved by longitudinally supporting the elongate channel **40** with a frame assembly **44** (FIG. **3**) rotatingly attached to the handle portion **22** over which a double pivot closure sleeve assembly **46** longitudinally moves to impart a closing and opening respectively to a distal and proximal motion to the anvil **42**, even with the staple applying assembly **20** articulated as in FIG. **2**.

With particular reference to FIG. **3**, the frame assembly **44** includes a single pivot frame ground **48** whose proximal end is engaged to the rotation knob **32**, with a right half shell **50** thereon shown in FIG. **3**. It should be appreciated that a proximal end of the closure sleeve assembly **46**, specifically of a closure straight tube **52**, encompasses the proximal end of the frame ground **48**, passing further internally to the handle portion **22** to engage closure components (not shown) that longitudinally translate the closure sleeve assembly **46**. A circular lip **54** at the proximal end of the closure straight tube **52** provides a rotating engagement to such components. Engaging components of the rotation knob **32** pass through a longitudinal slot **56** on a proximal portion of the straight closure tube **52** to engage an aperture **58** proximally positioned on the frame ground **48**. The longitudinal slot **56** is of sufficient length to allow the closure longitudinal translation of the closure sleeve assembly **46** at various rotational angles set by the rotation knob **32** to the closure sleeve assembly **46** and the frame ground **48**.

The elongate shaft **16** supports the firing motion by receiving a firing rod **60** that rotatingly engages firing components of the handle portion **22** (not shown). The firing rod **60** enters a proximal opening **62** along the longitudinal centerline of the frame ground **48**. The distal portion of the frame ground **48** includes a firing bar slot **64** along its bottom that communicates with the proximal opening **62**. A firing bar **66** longitudinally translates in the firing bar slot **64** and includes an upwardly projecting proximal pin **68** that engages a distal end **70** of the firing rod **60**.

The elongate shaft **16** supports articulation by incorporating a rectangular reservoir cavity **72**, one lateral portion depicted in a distal portion of the rotation knob **32**. A bottom compartment **74** that resides within the rectangular reservoir cavity **72** has laterally spaced apart left and right baffles **76**, **78**. An articulation actuator **80** slides laterally overtop of the bottom compartment **74**, its downward laterally spaced left and right flanges **82**, **84**, which are outboard of the baffles **76**, **78**, each communicating laterally to left and right push buttons **86**, **88** that extend outwardly from the respective shell halves of the rotation knob **32**. The lateral movement of the articulation actuator **80** draws left and right flanges **82**, **84** nearer and farther respectively to the left and right baffles **76**, 78, operating against left and right reservoir bladders 90, 92 of a fluidic articulation system 94, each bladder 90, 92 communicating respectively and distally to left and right fluid conduits or passageways 96, 98 that in turn communicate respectively with left and right actuating bladders 100, 102. The latter oppose and laterally pivot a T-bar 104 of the articulation mechanism 14.

The frame assembly 44 constrains these fluidic actuations by including a top and distal recessed table 106 of the frame ground 48 upon which resides the fluid passages 96, 98 and actuating bladders 100, 102. The T-bar 104 also slidingly resides upon the recessed table 106 between the actuating bladders 100, 102. Proximal to the T-bar 104, a raised barrier rib 108 is aligned thereto, serving to prevent inward expansion of the fluid passages 96, 98. The frame assembly 44 has a rounded top frame cover (spacer) 110 that slides overtop of the frame ground 48, preventing vertical expansion of the fluid passages 96, 98 and actuating bladders 100, 102, as well as constraining any vertical movement of the T-bar 104. In particular, the frame cover 110 includes features that enable it to also provide an articulation locking member 111, described in greater detail below as part of an articulation locking mechanism 113.

A distal end ("rack") 112 of the T-bar 104 engages to pivot a proximally directed gear segment 115 of an articulated distal frame member 114 of the articulation mechanism 14. An articulated closure ring 116 encompasses the articulated frame member 14 and includes a horseshoe aperture 118 that engages the anvil 42. A double pivoting attachment is formed between the closure straight tube 52 and articulating closure ring 116 over the articulating mechanism 14, allowing longitudinal closure motion even when the articulating mechanism 14 is articulated. In particularly, top and bottom distally projecting pivot tabs 118, 120 on the closure straight tube 52 having pin holes 122, 124 respectively are longitudinally spaced away from corresponding top and bottom proximally projecting pivot tabs 126, 128 on the articulating closure ring 116 having pin holes 130, 132 respectively. An upper double pivot link 134 has longitudinally spaced upwardly directed distal and aft pins 136, 138 that engage pin holes 122, 130 respectively and a lower double pivot link 140 has longitudinally spaced downwardly projecting distal and aft pins 142, 144 that engage pin holes 124, 132 respectively.

With particular reference to FIG. 4, the articulating closure ring 116 is shown for enhanced manufacturability to include a short tube 146 attached to an articulating attachment collar 148 that includes the proximally projecting pivot tabs 126, 128. Similarly, the straight closure tube 52 is assembled from a long closure tube 150 that attaches to an aft attachment collar 152 that includes the distally projecting pivot tabs 118, 120. The horseshoe aperture 118 in the short closure tube 146 engages an upwardly projecting anvil feature 154 slightly proximal to lateral pivot pins 156 that engage pivot recesses 158 inside of the elongate channel 40.

The illustrative version of FIG. 4 includes a dog bone link 160 whose proximal pin 157 pivotally attaches to the frame ground 48 in a frame hole 161 and whose proximal pin 159 rigidly attaches to a proximal undersurface 162 of the articulating frame member 114, thereby providing pivotal support there between. A bottom longitudinal knife slot 163 in the dog bone link 160 guides an articulating portion of the firing bar 66. The articulating frame member 114 also includes a bottom longitudinal slot 164 for guiding a distal portion of the firing bar 66.

Staple Applying Apparatus (End Effector)

With reference to FIGS. 4–5, the firing bar 66 distally terminates in an E-beam 165 that includes upper guide pins 166 that enter an anvil slot 168 in the anvil 42 to verify and assist in maintaining the anvil 42 in a closed state during staple formation and severing. Spacing between the elongate channel 40 and anvil 42 is further maintained by the E-beam 164 by having middle pins 170 slide along the top surface of the elongate channel 40 while a bottom foot 172 opposingly slides along the undersurface of the elongate channel 40, guided by a longitudinal opening 174 in the elongate channel 40. A distally presented cutting surface 176 of the E-beam 164, which is between the upper guide pins 166 and middle pin 170, severs clamped tissue while the E-beam actuates a replaceable staple cartridge 178 by distally moving a wedge sled 180 that causes staple drivers 182 to cam upwardly driving staples 184 out of upwardly open staple holes 186 in a staple cartridge body 188, forming against a staple forming undersurface 190 of the anvil 42. A staple cartridge tray 192 encompasses from the bottom the other components of the staple cartridge 178 to hold them in place. The staple cartridge tray 192 includes a rearwardly open slot 194 that overlies the longitudinal opening 174 in the elongate channel 40, thus the middle pins 170 pass inside of the staple cartridge tray 192.

The staple applying assembly 20 is described in greater detail in co-pending and commonly-owned U.S. patent application Ser. No. 10/955,042, "ARTICULATING SURGICAL STAPLING INSTRUMENT INCORPORATING A TWO-PIECE E-BEAM FIRING MECHANISM" to Frederick E. Shelton IV, et al., filed 30 Sep. 2004, the disclosure of which is hereby incorporated by reference in its entirety.

Articulation Locking Mechanism

In FIGS. 3–4, and 6–8, an articulation lock mechanism 200 is advantageously incorporated to maintain the staple applying assembly 20 at a desired articulation angle. The articulation lock mechanism 200 reduces loads on the left and right actuating bladders 100, 102. In particular, a compression spring 202 (FIG. 3) is proximally positioned between a proximal end 204 of the articulation locking member 111 and the handle portion 22, biasing the articulation locking member 111 distally. With particular reference to FIG. 4, two parallel slots 206, 208 at a distal end 210 of the articulation locking member 111 receive respectively upwardly projecting guide ribs 212, 214 on the frame ground 48. The guide ribs 212, 214 are longitudinally shorter than the parallel slots 206, 208 allowing a range of relative longitudinal travel. Thereby, with particular reference to FIG. 8, selective abutting engagement of a distal frictional surface, depicted as a toothed recess 216 distally projecting from the articulation locking member 111 is engaged to a corresponding locking gear segment 217 in a brake plate 218 received into a top proximal recess 220 of the articulating frame member 114. Distal and proximal holes 221, 222 in the brake plate 218 receive distal and proximal pins 223, 224 that upwardly project from the top proximal recess 220.

With particular reference to FIG. 6, the elongate shaft 16 is depicted in an articulated position with the closure sleeve assembly 46 removed from around the frame assembly 44 and without the elongate channel 40 and anvil 42. Articulation actuator 80 is shown moved laterally to the left to compress right proximal reservoir bladder 90 and expanded distal right actuation bladder 100 moving T-bar 104 to the position shown. Thus, lateral movement of the articulation actuator 80 articulates the distal frame 114 clockwise about the single pivot frame ground 48 as shown. The articulation actuator 80 advantageously also automatically engages and disengages the articulation lock mechanism **200**. In particular, a toothed detent surface **225** along a proximal top surface of the articulation actuator **80** receives an upwardly projecting locking pin **226** from the proximal end **204** of the articulation locking member **111**. The engagement of the locking pin **226** within the root of the toothed detent surface **225** provides sufficient distal movement of the articulation locking member **111** for locking engagement of the locking gear segment **217** in the brake plate **218**. Lateral movement by an operator of the compression member **272** proximally urges the locking pin **226** proximally, and thus disengages the articulation locking member **111** from the brake plate **218**. When the operator releases the articulation actuator **80**, the locking pin **226** is urged by the compression spring **202** into the adjacent detent in detent surface **225** to lock the locking mechanism **111**, and thereby the staple applying assembly **20**, constrains the articulation mechanism **14** at a desired articulation position by constraining and expanding the inflated shape of the proximal left and right reservoir bladders **90**, **92**.

Portions of the articulation lock mechanism **200** are described in greater detail in commonly-owned U.S. Pat. No. 5,673,841 A "SURGICAL INSTRUMENT" to Dale R. Schulze and Kenneth S. Wales, et al., filed 10 Mar. 1996, the disclosure of which is hereby incorporated by reference in its entirety.

Alternatively or additionally, an orifice may be provided within parallel fluid bladders **236**, **238** to control the flow rate between the proximal actuating bladders **100**,**102** and distal reservoir bladders **90**, **92**. In FIGS. **16**, **18**, the fluid passageways **258**, **264** may be sized to provide resistance to changing the angle of articulation, serving as the orifices or they may include a fluid flow rate limiting structure.

In FIG. **10**, an alternate locking mechanism **2000** of an articulation mechanism **2002** of a surgical instrument **2004**, is normally unlocked and is activated by cocking a laterally moving T-bar **2006** due to back loading. A slot **2008** is located in a frame ground **2010** to receive and guide a rib **2012** extending down from the T-bar **2006**. A slender longitudinal section **2014**, which is orthogonally attached to the rib **2012** deflects if an end effector **2016** is backloaded. For instance, as the end effector **2016** is forced to the right as depicted at arrow **2018**, for instance, its proximal gear segment **2020** acts upon a rack **2022** of the T-bar **2006**, imparting a nonorthogonal backdriving force, as depicted at arrow **2024**. Thus, the slender longitudinal section **2014** bends, cocking rib **2012** in slot **2008**. This cocking produces opposing binding forces, as depicted by arrows **2026**, **2028**, that lock the T-bar **2006** and prevent further articulation. Unlocking occurs when actuation of the articulation bladders uncocks the laterally moving T-bar **2006**. Thereafter, the rib **2016** may assist in guiding the T-bar **2006**.

In FIG. **11**, yet an additional articulation locking mechanism **2100** for a surgical instrument **2102** is depicted that is normally unlocked and activated by the proximal force vector from the 20 degree pressure angle from gear teeth **2104** of an end effector **2106** and rack teeth **2108** of a T-bar **2110**. When the end effector **2106** is backloaded, as depicted by nonorthogonal arrow **2112**, the longitudinal vector of the pressure angle, depicted as arrow **2114**, moves the T-bar **2110** proximally. This longitudinal force vector is applied to a stiff spring **2118** behind a rack **2120** of the T-bar **2110**. When the spring **2118** deflects as T-bar **2110** moves proximally, locking teeth **2126** projecting proximally from the rack **2120** are brought into engagement while locking elements **2122** proximally and laterally aligned on a ground frame **2124** are brought into engagement with locking teeth **2126** projecting proximally from the rack **2120**. The locking teeth **2126** and locking elements **2122** disengage when the proximal force vector is reduced or eliminated by removing the back loading of the end effector **2106** and allowing T-bar **2110** to move distally from urging from spring **2118**.

Double Pivot Closure Sleeve and Single Pivot Frame Ground Combination

With reference to FIGS. **3**-**4** and **7**, the implement portion **12** advantageously incorporates the double pivot closure sleeve assembly **46** that longitudinally translates over and encompasses a single pivot frame ground **48**. These mechanisms and their operation will now be described in further detail. With particular reference to FIG. **7**, the articulation mechanism **14** is depicted in an articulated state with the closure sleeve assembly **46** retracted proximally to an anvil open state. With the anvil **42** open, actuation of the articulation control **18** causes the articulated closure ring **116** to pivot about the upwardly directed distal pin **136** and downwardly directed distal pin **142** respectively of the upper and lower double pivot closure links **134**, **140**. The frame ground **48** pivots around a single pin, depicted as the proximal pin **1808** that joins frame ground **48** to distal frame member **114**. With the anvil **42** open, the proximal pin **147** of frame ground **48** is aligned with the distal most position of upper and lower double pivot links **134**, **140** of the closure sleeve assembly **46**. This positioning allows easy pivoting and rotation of the staple applying assembly **20** while the anvil **42** is open. When the closure sleeve assembly **46** is moved distally to pivot anvil **42** closed, the closure straight tube **52** moves distally about frame ground **48** and the articulated closure ring **116** moves distally along the articulated distal frame member **114** axis as urged by pivot links **134**, **140**. Dual pivoting pins **136**, **138** and **142**, **144** on links **134**, **140** facilitate engagement with closure straight tube **52** and articulated closure ring **116** as they are urged towards the distal closure position when the device is articulated (not shown). At the distal closure position, the frame ground pivot pin ("proximal pin") **147** is vertically aligned with proximal pivot pins **138**, **144** at full articulation or may fall at any point between distal pins **136**, **142** and proximal pins **138**, **144** while working effectively.

Solid Firing Bar Support

In FIG. **8**, the articulation mechanism **14** of FIG. **7** is partially exploded and viewed from the bottom, showing a solid wall firing bar support design (dog bone link **160**) that offers advantages over conventional flexible support plates. Support plates are used to bridge the gap and guide and support the firing bar **66** through a single frame ground pivot articulation joint **1801**. Flexible firing bars are known, but the incorporation of solid wall firing bars such as those shown in FIGS. **4**, **8** and **9** offer unique advantages. Referring now to FIG. **8**, frame ground **48** includes a frame knife slot **1802** that runs along the bottom of frame ground **48** and a distal knife slot **164** runs along the bottom of an articulating distal frame member **114** for the sliding reception of the firing bar **66** (not shown) therein. Frame ground **48** is described above and includes a direct single pivotal connection **1808** with the distal frame member **114**. The fixed wall dog bone link **160** that is rotatably connected on proximal pin end **157** and movably connected on distal pin end **159** includes left and right lateral guides **1818**, **1820**, defining therebetween a guidance slot **1822** for sliding passage of a firing bar **66** (FIG. **4**).

Thus, to bridge the gap between frame ground **48** and the distal frame member **114**, the fixed wall pivoting dog bone link **160** is pivotally attached to frame ground **48** and is slidingly attached to frame member **114**. Proximal pin **157** of the pivoting dog bone **160** is pivotally received in a bore **1824** in frame ground **48** enabling pivotal dog bone **160** to pivot about pocket bore **1824**. The distal pin **159** extends upwards from pivotal dog bone **160** and is slidingly received in a slot **1826** in distal frame **114**. Articulation of staple applying assembly **20** to an angle of such as 45 degrees from the longitudinal axis pivots pivoting dog bone **160** in bore **1824** at its proximal pin **157**, and distal pin **159** slides into slot **1826** at its distal end **1814** to bend firing bar **66** to two spaced -apart angles that are half of the angle of the staple applying assembly **20**. Unlike previously referenced flexible support plates that bend the firing bar **66** to a 45 degree angle, the fixed wall pivoting dog bone **160** bends the firing bar **66** to two spaced -apart angles of such as 22.5 degrees each. Bending the flexible firing bar or bars **66** to half the angle cuts the bend stress in the firing bars **66** to one -half of that found in conventional articulation supports. Reducing the bending stress in the firing bars **66** reduces the possibility of permanently bending or placing a set in the firing bars, reduces the possibility of firing jams, ensures lower firing bar retraction forces, and provides smoother operation of the firing system.

In FIG. **9**, a surgical instrument **1900** includes double closure pivot. Single frame pivot articulation joint **1902** shows an alternate solid wall support plate mechanism **1904** that replaces the lower double pivot link **140** and dog bone link **1812**. Left and right firing bar supports **1906**, **1908** extend upwardly from a lower double pivot link **1910** of a closure sleeve assembly **1912**. Clearance **1914** is provided in a frame ground **1916** for the firing bar supports **1906**, **1908** to travel as the closure sleeve assembly **1912** moves distally to close the anvil **42** (not shown in FIG. **9**) and proximally to open anvil **42**. Like the above described pivoting dog bone **1812**, the alternate lower double pivoting link **1910** also bends and supports the firing bar **66** (not shown in FIG. **9**) creating two spaced apart bend angles that are up to one-half of the bend angle of the staple applying assembly **20**.

Lateral Member Guide Mechanisms

With further reference to FIG. **9**, left and right upward flanges **1918**, **1920** on the frame ground **1916** include distal and proximal lateral pin guides **1922**, **1924** that pass laterally through holes in a T-bar **1926** assisting in minimizing binding in an articulation mechanism **1928**. As another example, in FIG. **7**, the T-bar **104** advantageously included a dovetail lateral guide **1930** that laterally slides within a dovetail channel **1932** formed therein. As yet a further example, in FIG. **12**, a raised rib **1934** on a frame ground **1936** is received within a rectangular slot **1938** formed in a T-bar **1940**. To further facilitate non-binding lateral translation, distal and proximal lateral bearing tracks each include a respective plurality of ball bearings **1946**, **1948**. As yet a further example, in FIG. **13**, a plurality of frame lateral grooves **1950**–**1954** are formed in a frame ground **1956** with corresponding T-bar lateral grooves **1958**–**1962** in a T-bar **1964**. Slide rollers **1966-1970** reside trapped within respective pairs of lateral grooves **1950**/**1958**, **1952**/**1960**, **1954**/**1962**. These are by no means an exhaustive list of lateral guidance members that prevent unwanted cocking or rotation of the T-bar **1940**.

Double Pivot Frame Ground and Single Pivot Closure Combination

In FIGS. **14**–**15**, an alternate frame ground and closure mechanism **2200** includes a surgical instrument **2202** that includes double pivoting frame assembly **2204**. In particular, a frame ground **2206** is connected to distal frame member **2208** by a dual pivot frame dog bone **2210** having a proximal pivot pin **2212** pivotally engaging a proximal bore **2214** in frame ground **2206** and a distal pivot pin **2216** engaging a distal bore **2218** of distal frame member **2208**. A guidance slot **2220** is located on the underside of dog bone **2210** for the guidance of a firing bar **66** (not shown in FIGS. **14**–**15**) therein. Knife slot **2222** is located in distal frame member **2208**. As shown, articulation of the closure ring **2230** to a 45 degree angle articulates distal frame member **2208** to a 45 degree angle and articulates frame dog bone **2210** to half that angle. Consequently, firing bar **66** is subjected to the two shallow half bends that are spaced apart and obtains all the benefits listed above.

Outermost closure sleeve assembly **2224** is different in that only one pivot axis of the double pivoting design of the frame assembly **2204** accommodates its longitudinal closure motion. As shown, a closure tube shaft **2226** has a clevis **2228** at a distal end. Clevis **2228** is pivotally engaged with a closure ring **2230**. Closure ring **2230** has a proximal gear **2232** formed at a distal end and pin **2234** pivotally engages an upper tang **2236** of clevis **2228** and a lower arm **2238** engages with a lower tang **2240** of clevis **2228**. Holes **2242** in the clevis **2228** receive lateral guides pins **2243** and slidably attach a T-bar **2244** therein to engage proximal gear **2232** of the closure ring **2230**. Thus, this alternate mechanism **2200** uses a reversed single/dual pivot alternate concept from the previously described mechanism. That is, the alternate closure mechanism has a single pivot and the alternate frame ground has a dual pivot, unlike the previously described dual pivot closure mechanism with a single pivot frame ground.

Laterally Moving Articulation Mechanism

In FIGS. **16**–**19**, a laterally moving articulation mechanism **230** is depicted schematically to show lateral motion being used to effect articulation of an end effector **232**. Lateral motion is the movement of at least one element toward or away from the longitudinal axis of a surgical device **234**. This motion is generally at right angles to the longitudinal axis, which is a horizontal line bisecting the mechanism **230**, and does not involve rotational motion or longitudinal motion. Laterally moving articulation mechanisms can be fluid actuated as shown in FIGS. **16**–**19** or mechanically actuated as shown in FIGS. **20**–**23**.

Laterally Moving Fluid Articulation Mechanism

The laterally moving articulation mechanism **230** is shown schematically in FIGS. **16**–**19** and includes a fluid control system **235** having fluid-filled parallel left and right fluid bladders **236**, **238** extending longitudinally therein that move a lateral member or T-bar **240** laterally by the movement of fluids **242**. All directions are in reference to the longitudinal axis. Referring to the unarticulated view of FIGS. **16** and **17**, the distally located end effector **232** pivots about pin **244** and has a gear segment **246** at a proximal end. Pivot pin **244** is attached to a frame (not shown). A rack **248** at a distal end of the T-bar **240** operably engages gear segment **246**. T-bar **240** and rack **248** are laterally moveable along axis A—A. A distal portion of the long left and right fluid bladders **236**, **238** lie laterally to the laterally moveable T-bar **240** and are laterally constrained within a closure sleeve **250** and vertically constrained by a frame **252** below and a spacer **254** above. Left actuating fluid bladder **236** is filled with fluid **242** and has left distal actuating bladder **256**, left fluid passageway **258**, and a left proximal reservoir bladder **260**. Right fluid bladder **238** contains fluid **242** and has a right distal actuating bladder **262**, right fluid passageway **264**, and right proximal reservoir bladder **268**. A fixed divider **270** extends from the frame **252** and separates the bladders **260**, **268** and the fluid passageways **258**, **264**. The fixed divider **270** and the closure sleeve **250** constrain the fluid passageways **258**, **264** and prevent expansion in the fluid passage sections **258**, **264** of the bladders **236**, **238**. A laterally moveable "C" shaped compression member **272** is included in articulation control mechanism **230** for the compression of one of the proximal reservoir bladders **260**, **268** and the articulation of the end effector **232**. In addition, other components such as a firing bar **274** passing through a firing bar slot **276** in the frame **252** may be incorporated (FIGS. **17**, **19**).

As shown in FIGS. **2** and **18**-**19**, lateral movement of C-shaped compression member **272** to the left compresses right proximal reservoir bladder **260** forcing fluid into right fluid passageway **258** and right distal actuating bladder **256**. As right distal actuating bladder **256** moves T-bar **240** laterally to the left, the left distal actuating bladder **262** is compressed and the end effector **232** is articulated to the right (clockwise as viewed from the top as shown). Compression of the left distal actuating bladder **262** causes fluid to flow proximally through the left fixed fluid passageway **264** and into left proximal reservoir bladder **266**. In particular, an attached right wall **280** of the C shaped compression member **272** moves to the left causing compression of the right proximal reservoir bladder **260**. A corresponding movement left of an attached left wall **278** of the C shaped compression member **272** provides space for the fluid from compressed left reservoir bladder **262** as the fluid flows into the expanding left proximal reservoir bladder **266**.

This fluid control system **235** for the articulation mechanism **230** offers at least several advantages. First, the orientation of the actuating bladders **256**, **262**, proximal to the articulation joint or mechanism **230**, allows the use of long bladders **236**, **238** and longer T-bars **240** within the instrument **234**. As a fluid-driven system, increasing the output force of the fluid control system **235** may be accomplished in two ways. First, for a fixed fluid area on the T-bar **240**, the fluid pressure onto the fixed area may be increased. Second, for a fixed fluid pressure, the fluid contact area on the T-bar **240** may be increased. The first method results in a more compact design and higher system pressures. The second method results in a larger design and lower system pressures. To decrease cost, simplify the design, reduce system stress, and reduce risk of bladder rupture, the illustrative version depicts long distal actuating bladders **256**, **262** in an advantageous position proximal to the articulation mechanism **230** within an elongate shaft of the instrument. It is this placement of the bladders **256**, **262** that enable the bladders **256**, **262** to be long and the articulation output force to be high for a low input pressure.

Thus, the output force of the articulation mechanism **230** can be increased (for the same input pressure) simply by increasing the pressure contact area of the distal balloons **256**, **262** on T-bar **240**. Pressure contact area increases are restricted to height and length. Since the diameter of conventional endoscopic surgical instruments are fixed at certain diameters to pass through insufflation ports, this limits the height change. Changing the length of the pressure contact area has the greatest effect and enables the lateral output force of the device to be advantageously tuned (by changing length) to meet whatever output force the system requires.

Fluids used in a laterally moving device can be either compressible or incompressible. As used herein, the term "fluid" comprises liquids, gases, gels, microparticles, and any other material which can be made to flow between a pressure gradient. While any fluid can be used, sterilized solutions such as saline, mineral oil or silicone are especially preferred.

Laterally Moving Mechanical Articulation Mechanism

Whereas fluid mechanisms are described above to cause lateral movement and articulation, mechanical mechanisms may accomplish a similar lateral motion as produced by fluid bladders **206**, **208**. In FIGS. **20**-**21**, an alternate laterally moving articulation mechanism **300** employs a mechanical control system, in particular a longitudinally moving member, to affect lateral motion and articulation for a surgical instrument **301**. In the illustrative version, with particular reference to FIG. **20**, a laterally moving slide bar **302** has at least one pair of angled left and right cam surfaces **304**, **306** extending laterally therefrom on opposite sides of an elongate longitudinal shaft **308**. In the illustrative version, another pair of proximal left and right angled cam surfaces **310**, **312** are also included. A right longitudinally moving link **314** includes corresponding inwardly directed distal and proximal counter ramped surfaces **316**, **318** that register and slidingly engage to distal and proximal right cam surfaces **306**, **312** such that distal longitudinal movement of the moving link **312** causes leftward lateral movement of the slide bar **302**. It should be appreciated that this ramping contact may be reversed such that distal movement causes rightward movement respectively.

It should be appreciated that a spring bias (not shown) may be included on the slide bar **302** to urge the slide bar **302** rightward into engagement with the right longitudinally moving link **314** so that the opposite proximal movement of the right longitudinal moving link **314** causes leftward movement of the slide bar **302**. Alternatively, in the illustrative version, a left longitudinally moving link **320** includes corresponding inwardly directed distal and proximal counter ramped surfaces **322**, **324** that register and slidingly engage to distal and proximal right cam surfaces **304**, **310**, the latter ramp distally and the former ramp proximally so that distal longitudinal movement of the left longitudinally moving link **320** causes rightward lateral movement of the slide bar **302**. It should be appreciated that this ramping contact may be reversed such that proximal movement causes leftward movement. It should be appreciated that the right and left longitudinally moving links **314**, **320** and sliding bar **302** are supported within an elongate shaft **326** that allows this longitudinal movement of the former and lateral movement of the latter.

A distal end of the slide bar **302**, depicted as a socket ball **328**, is received within a V-shaped cam groove **330** proximally aligned and proximal to a pivot pin **332** of an end effector **334**. Thus, in FIG. **21**, proximal movement of the right longitudinally moving link **314** and distal movement of the left longitudinally moving link **320** causes rightward movement of the sliding bar **302** with a corresponding rightward movement of the socket ball **328**. Thus the V-shaped cam groove **330** is driven rightward, pivoting its most distal end **336** to the left. Alternatively, lateral movement of the slide bar **302** may be converted to articulation of the end effector **334** by the rack and gear engagement described above with respect to FIGS. **16**-**19**. Thus, mechanical systems that use longitudinal movement can be used to provide lateral articulation for the surgical instrument **301**.

Rotatable Link

In FIGS. **22** and **23**, a further alternate articulation mechanism **400** uses a rotatable link **402** to move a lateral member, depicted as laterally moving slide bar **404**, to cause articulation for a surgical instrument **406**. The laterally moving slide bar **404** may operably engage with a rotary gear or a cammed groove as described above for FIGS. **16** and **20** at a proximal end of an end effector (not shown). Rotatable link **402** may be located below the slide bar **404** with at least one arm **408** extending rotatably transverse to the longitudinal axis therefrom to engage within a socket **410** within the slide bar. The slide bar **404** is vertically constrained between a top spacer **412** and a bottom frame **414**, the later having a longitudinal trough **416** that receives the rotatable link **402** and accommodates rotation of the arm **408**. The spacer **412** and frame **414** are encompassed by a tubular sleeve **418**. Rotation of the rotary link **402** moves the arm **408** in an arc and thereby moves the slide bar **404** laterally in the direction of rotation.

Articulation Mechanism Having Opposing Buckling Flexible Members

In FIG. **24**, a surgical instrument **500** has a slide member **502** aligned along a longitudinal axis of an elongate shaft **504** and allows lateral movement between a left buckling member **506** and a right buckling member **508** and is vertically constrained by a frame and spacer (not shown). Each buckling member **506**, **508** has a respective fixed distal attachment **510**, **512** and a longitudinally translatable proximal link **514**, **516**. Respective left and right flexible members **518**, **520** inwardly bow in opposition against the slide bar **502**, with the amount of lateral intrusion in relation to distal longitudinal movement of their respective proximal link **514**, **516**. In an unarticulated state shown in FIG. **24**, the proximal links **514**, **516** are not differentially positioned, and thus a distally projecting tip **522** of the slide member **502** is centered within a V-shaped cam groove **524** that proximally opens relative to a pivot pin **526** of an end effector **528**. In FIG. **25**, the left proximal link **514** has been distally advanced and the right proximal link has been proximally retracted, causing the slide bar **502** to laterally translate to the right, thereby causing camming of the distally projecting tip **522** against a right portion of the V-shaped cam groove **524** with resultant leftward articulation of the end effector **528** about the pivot pin **526**.

Electromagnetic Lateral Articulation Control Mechanism

In FIG. **26**, a surgical instrument **600** has a distally connected end effector **602** that is selectively articulated in an arc about its pivot pin **604** relative to an elongate shaft **606** by lateral motion of a slide bar **608**. In particular, a distal socket **610** of the slide bar **608** engages a V-shaped cam groove **612**, opening proximal to the pivot pin **604**. The slide bar **608** is vertically constrained within the elongate shaft **606** by a frame and spacer (not shown). Left and right compression springs **614**, **616** that are inwardly directed on opposite lateral sides of the slide bar **608** are proximate to a distal end **618** of the elongate shaft **606**. These springs **614**, **616** provide a centering bias on the slide bar **608** and thus on the end effector **602**. Left and right electromagnets **620**, **622** on opposing sides of the slide bar **608** are selectively activated to attract a ferrous target **624** integral or affixed to the slide bar **608**, thereby selectively displacing the slide bar **608** laterally and effecting articulation of the end effector **602**, as depicted in FIG. **27**. For simplicity, a longitudinally-aligned coil is depicted, although it should be appreciated that one or more electromagnets may be aligned to produce a magnetic field perpendicular to the slide bar **608**, such as a plurality of coils (not shown) aligned along the longitudinal length of the slide bar **608** with each coil having its longitudinal axis aligned with the lateral movement axis of the slide bar **608**.

While the present invention has been illustrated by description of several embodiments and while the illustrative embodiments have been described in considerable detail, it is not the intention of the applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications may readily appear to those skilled in the art.

For instance, a single fluid transfer approach may be incorporated wherein a single fluid actuator expands and compresses to effect articulation, perhaps assisted by a resilient opposing member that is not in fluid or pneumatic communication to the handle. An application consistent with such a design, for instance, could include just one bladder attached to a T-bar so that when compressed by the withdrawal of fluid, it pulls the T-bar with it.

What is claimed is:

1. A surgical instrument, comprising:

an end effector including a proximal camming surface;

an elongate shaft, wherein the elongate shaft defines a longitudinal axis, the elongate shaft further including a frame defining a lateral recess aligned with the longitudinal axis, wherein the lateral recess is proximate to a distal end of the elongate shaft;

an articulation joint pivotally attaching the end effector to the distal end of the elongate shaft comprising a pivot axis distal to the proximal camming surface;

a slide bar sized for lateral movement within the lateral recess and having a distal portion engaged to the proximal camming surface of the end effector to effect articulation of the end effector, wherein the slide bar is movable laterally relative to the longitudinal axis to effect articulation of the end effector;

a lateral guide mechanism engaging the slide bar to the frame, wherein the lateral guide mechanism is operable to move the slide bar laterally relative to the longitudinal axis while maintaining parallel alignment of the slide bar to the longitudinal axis of the elongate shaft; and

a handle portion proximally attached to the elongate shaft and operably configured to produce an articulation motion to laterally move the slide bar;

wherein the proximal camming surface of the end effector comprises a gear segment and the distal portion of the slide bar comprises a gear rack;

wherein the lateral guide mechanism comprises a channel formed laterally in the frame and a rib received in the channel, perpendicularly attached to the slide bar further comprising a flexible longitudinal portion connecting the rib to the gear rack, wherein manipulating the end effector causes backdriving of the gear segment that flexes the longitudinal portion, cocking the rib into binding engagement in the channel.

2. The surgical instrument of claim **1**, wherein the proximal camming surface of the end effector comprises a proximally directed camming recess that receives the distal portion of the slide bar.

3. The surgical instrument of claim **1**, wherein the lateral guide mechanism engaging the slide bar to the frame for lateral and longitudinally aligned movement of the slide bar comprises a rotatable link aligned parallel to the slide bar and aligned with a vertical centerline of the shaft, the rotatable link pivotally joined to a near surface of the slide bar causing lateral movement thereof as the rotatable link rotates.

4. The surgical instrument of claim **3**, wherein the rotatable link includes a plurality of pivotal joinings to the slide bar spaced along a longitudinal length thereof to maintain the alignment during actuation.

5. The surgical instrument of claim **1**, wherein right and left distal fluid actuated bladders are placed on respective sides of the slide bar, the handle portion including an articulation control operatively configured to differentially transfer fluid to the right and left distal fluid actuated bladders, wherein the left and right distal fluid actuated bladders together have a combined volume, wherein the combined volume of both the left and the right distal fluid actuated bladders remains constant as fluid is transferred from one to the other to move the slide bar in a selected lateral direction.

6. The surgical instrument of claim **1**, wherein right and left mechanical actuators are placed on respective sides of the slide bar, the handle portion including an articulation control operatively configured to exert differential longitudinal motions to the right and left mechanical actuators to laterally displace the slide bar.

7. A surgical instrument, comprising:

a staple applying assembly, wherein the staple applying assembly has a proximal camming surface;

an elongate shaft attached to the staple applying assembly, wherein the elongate shaft defines a longitudinal axis, the elongate shaft further including a frame defining a recess aligned with the longitudinal axis;

an articulation joint pivotally attaching the staple applying assembly to a distal end of the elongate shaft;

a slide bar within the recess, wherein the slide bar is movable laterally relative to the longitudinal axis, the slide bar having a distal portion engaged to the proximal camming surface of the staple applying assembly, wherein the slide bar is positioned to impart an articulation rotation to the end effector in proportion to a lateral position of the slide bar within the recess;

right and left actuators on respective sides of the slide bar in the recess, wherein the right and left actuators are operable to move the slide bar laterally relative to the

longitudinal axis to selectively laterally position the slide bar within the recess of the elongate shaft;

a means for laterally guiding the slide bar within the recess defined by the frame, maintaining the slide bar in parallel alignment with a longitudinal axis of the shaft during lateral movement of the slide bar relative to the longitudinal axis in response to the actuators; and

a handle portion proximally attached to the elongate shaft and operably configured to produce differential longitudinal motions to respective actuators to laterally move the slide bar relative to the longitudinal axis,

wherein the proximal camming surface of the staple applying assembly comprises a gear segment and the distal portion of the slide bar comprises a gear rack;

wherein the means for laterally guiding the slide bar comprises a channel formed laterally in the frame and a rib received in the channel, perpendicularly attached to the slide bar further comprising a flexible longitudinal portion connecting the rib to the gear rack, wherein manipulating the staple applying assembly causes backdriving of the gear segment that flexes the longitudinal portion, cocking the rib into binding engagement in the channel.

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